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Wisconsin Geological Survey reports

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Annual report on the Geological Survey of the State of Wisconsin, 1855-1856

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ANNUAL REPORT

OF THE

GEOLOGICAL SURVEY

OF THE

STATE OF WISCONSIN.

BY JAMES G. PERCIVAL.

MADISON:
CALKINS & PROUDFIT, PRINTERS.
1856.

PREFACE.

It appears to have been the design of Dr. Percival to include in this report further remarks under the heads of

The conformation of the surface.

The character of the soils, their agricultural capabilities and connexion with vegetation, particularly forest trees.

The metalic ores.

Minerals useful in the arts and in agriculture.

The surface deposits; and

The effects of primary and ignious rocks upon the lead mines, showing the object of much of his detailed survey under the head of "Surface Arrangement," &c. &c.

NOTE.

While Dr. Percival was engaged in preparing his second annual report of the geological survey of the State of Wisconsin, he was attacked by a disease which terminated in his death on the 2d day of May, 1856. The unfinished manuscript has been carefully copied and prepared for the press, but it is undoubtedly far from possessing that degree of finish and completeness that would have been given it, had its distinguished author been spared to complete this important portion of his labors.

It is deemed not improper here to insert the following brief obituary notice, taken from the July number of the American Journal of Science, published at New Haven, by Professors Silliman and Dana.

DEATH OF DR. JAMES G. PERCIVAL.

Died, on the 2d of May, 1856, at Hazel Green, Wis., in the 61st year of his age, Dr. James Gates Percival, eminent as a poet, scholar, and philosopher.

He was born in the village of Kensington, in the town of Berlin, in Connecticut, September 15th, 1795. At an early age he manifested the poetical ability and general intellectual power for which in after life he was so distinguished. He entered Yale College in 1810, but on account of ill health he did not graduate until 1815. During his collegiate course he was eminent for scholarship, although he devoted much time to general studies and to the cultivation of his poetical powers. He studied the profession of medicine, receiving his degree of M. D. in 1820, but he never engaged in the practice. His first volume of poems was published in 1820, his last in 1843. His verse shows great force and freshness of expression, a fertile imagination, and remarkable rhythmical skill. Many of his songs have taken permanent rank in American literature. Chiefly as a poet will he be remembered, but we must here speak of him in other relations.

In 1824 he was for a short time in the service of the United States as Professor of Chemistry in the Military Academy of West Point, and subsequently as a surgeon connected with the recruiting service at Boston. But he preferred solitary study, and gave himself to philological and historical researches, and to general literary pursuits. Having great readiness in acquiring languages, he soon became a critical scholar in most of the modern European tongues, and composed verses in many of them.

In 1827 he was employed to revise the manuscript of Dr. Webster's large Dictionary, and to this work he rendered a service much more important than is commonly supposed. He was from time to time engaged in various literary labors, as editor and translator. Among the works which he published may be named a revised translation of Malte Brun's Geography, and a Sketch of the Varieties of the Human Race, and their linguistic relations, a tract drawn chiefly from the Mithridates of Adelung and Vater, and printed in 1831.

Always an ardent lover of nature, and fond of out-door explorations, he combined with his literary pursuits, the study of natural history and geology. In 1835 he was appointed in conjunction with Prof. C. U. Shepard, to make a survey of the geology and mineralogy of the State of Connecticut. Dr. Percival took charge of the general geology, and explored the whole State thoroughly and minutely on foot. He collected materials for a report so full and extensive that it was thought inexpedient to offer the whole for publication, and he consequently presented only a brief summary thereof. This report was issued at New Haven, in 1842, in an octavo volume of 495 pages, accompanied by a geological map. The work is prepared with great minuteness and precision of detail, but in a manner too much condensed to be very attractive or popular.

He spent the summer of 1853 in the service of the American Mining Company, in exploring the lead mines of Illinois and Wisconsin, and gave such satisfaction to the inhabitants of that region, that the next year he was offered a commission as State Geologist of Wisconsin. His first annual report on that survey was published at Madison, Wisconsin, in January, 1855, in an octavo volume of 101 pages. The larger part of that year he also spent in the field. While engaged in preparing his second report in January, 1856, his health began to fail, and after a few months of decline he passed away.

Dr. Percival possessed intellectual faculties of a very high order, and few men have exceeded him in variety and exactness of learning.

GEOLOGICAL SURVEY.

To His Excellency Coles Bashford,
Governor of Wisconsin.

In presenting my Annual Report on the geological survey of the state, it may be proper to give a brief narrative of my proceedings in pursuing the object of the survey.

The winter (1854–5) had been employed in preparing and attending to the publication of my last report; and after a short visit to the east, which my private affairs rendered necessary, I recommenced my explorations early in April. I first visited the iron mines, at Iron Ridge, Dodge county, and at Hartford, Washington county, and at Marston, on the Little Baraboo, Sauk county, examining also such other objects of interest as occurred on my route. After this excursion, I recommenced (May 1st) the examination of the lead district, left unfinished the former season, and completed it June 30th. I have employed the remainder of the season, till December 8th, in a reonnoissance of the state, for the purpose of forming a general idea of the geological arrangement. In so doing, I have aimed to traverse as much of the state as possible; and while the determination of the different strata and formations has been my leading object, I have improved every opportunity of visiting such localities as were of particular importance. I have visited in this and my other pursuits, thirty-eight of the fifty counties in the state, all, indeed, except a few of the more nothern and less settled counties. I first made a tour (July—August) through the north-eastern counties as far as Sheboygan, Green Bay and Stevens Point. I then proceeded (September—October) on an excursion through the western counties, north of the Wisconsin, as far as the Falls of St. Croix, and from the want of communication on the Wisconsin side, near the Mississippi, returned on the west side of that river, through Minnesota, from the St. Croix to La Crosse. During November, I made a tour through the south-eastern counties, and thus have been able to take a general view of the largest and, at present, the most important part of the state.

In making this general examination, I have not only had in view objects of direct geological interest, but also the agricultural capabilities of the surface, and have been agreeably surprised to find in the more nothern districts, but a small extent not capable of improvement.

The importance of such a general examination as I have made, however hasty it may have been, will, I trust, be obvious. It has enabled me to form a connected view of the geological arrangement; and in all my observations, should I continue the survey, will furnish me a guide through any difficulties I may encounter. The statements, which I shall make in this report, will, I hope, render similar aid to others who may engage in the same pursuit. I have endeavored to determine with exactness, and believe that the statements I shall make will stand the test of observation. In several instances I have found occasion to differ from the reports of former geologists. I have done so on (to me) satisfactory grounds. A comparison of my statements with those in former reports, particularly as exhibited in the maps, will show you how far I have differed.

Some of these differences will be of much practical importance. Thus the peninsula east of Green Bay has been marked as occupied by the upper magnesian limestone (Owen's Rep. 1852). I am satisfied that it should be marked as occupied by the mound limestone, at the base of which is the position of the Dodge county iron ore. The eastern shore of that bay is thus the line along which that ore may be traced, and from indications already discovered perhaps with success.

The limestones of the upper Mississippi have been referred (Orrin's Reports, 1848 and 1852) to the lower magnesian and blue limestone. My observations have led me to consider them as beds subordinate to the lower sandstone. The occurrence of such extensive beds of limestone in that formation offers much additional encouragement to the prospects of deep mining in the lead district. All the different beds of limestone there reached have been found mineral bearing, and if the extensive beds, which I think I have traced in the lower sandstone in the north-eastern counties, should extend, as may be considered probable, beneath the lead district, and there, like the known limestone in that district, should prove mineral bearing, the fild for operations in a downward direction would be largely increased.

A few instances have occurred, where the sandstones, both upper and lower, appear to be traversed by metalic substances, in a manner similar to the limestones in the mineral openings. A remarkable instance of this occurs in the upper sandstone on Skinner's branch, Green county, where the whole depth of the rock is traversed by iron ores, (iron pyrites and oxyds formed from it); and the deposits of copper with iron at Copper Creek, near the Baraboo, and of the brown hematite at Marston, on the Little Baraboo, show a similar arrangement in the lower sandstone.— These facts are encouraging to the prospect of tracing the mineral veins in the lead district through the siliceous strata.

I have ascertained this season that lead has been found in the same strata as in the mineral district, (the upper magnesian, blue limestone, and lower magnesian,) in different places remote from it, toward the north-east, as far at least as the vicinity of Oshkosh, on lake Butte des Morts.

But in these remote localities it has been found only in small quantity, not sufficient to offer present encouragement.

I have examined at different points an extensive range of sienitic rocks, not laid down in former maps and reports, traversing the country from the south side of Fox river through Marquette and Waushara counties, and apparently, from its arrangement, having an important bearing on the phenomena of the lead district, as well as on the general arrangement of the secondery strata, south and east. The extensive ranges of grey quartzite in the Baraboo country and east of Portland have also an apparent connexion with the same.

It is an interesting fact that the principal falls and rapids of the larger rivers in the northern part of the state are formed by the passage of primary rocks. Only a few of the smaller falls and rapids are formed by the passage of beds of limestone. The falls and rapids of the Lower Fox river, are formed by beds of limestone, apparently of the upper magnesian.

In presenting this report, I do not offer the details of my survey, but only such a summary as may be of practical importance. I trust I shall be able to offer many facts in my report on the mineral district, still more encouraging to the prospects of mining in the lower strata; (the blue limestone and lower magnesian,) than those I have offered in my former report. I have been employed this season in examining the more northern mines, which I have found to a large extent—situated in the two upper beds of the blue limestone. Some of the largest and most productive diggings have been there worked in that rock, praticularly those at Black-Jack, Crow Branch, Centerville and Franklin. My observations this season, will enable me to mark with more precision the characteristics and position of the different openings in that rock, as well as in the lower magnesian. As a general result, I am still more strongly persuaded of the probability of continued deep mining, and that by scientifically combining the facts observed in the different diggings, rules may be determined which will enable mining to be conducted with more certainty and less outlay of capital than it has yet been. The probabilities of deep mining, offered by the calcareous beds in the lower sandstone, I have already hinted at.

Next to the lead mines in importance, if not even more important to the ultimate prosperity of the state, are the iron mines. The very extensive beds of lenticular red oxyd at Iron Ridge and Hartford; the deposits of brown hematite found in the counties north of the Wisconsin, particularly at Marston, Sauk county, and the Iron Mountain, Crawford county, the primary ores in the northern districts, particularly those in the vicinity of Black River Falls; and even the Bog Ores, so extensively diffused through the marshes of the state, particularly in the south-eastern counties, offer inexhaustible supplies of that most valuable metal, and in the most important instances, in the vicinity of extensive forests. My examinations have not yet offered me any encouragement for the discovery of coal in the state; and when we consider that the highest known rocks in the state are regarded as the third formation below the coal measures, the probability of such discovery is very remote. Still with the great supplies of fuel in the forests of the state, and the facilities of transportation from the coal-fields toward the south, which the numerous railroads in that direction will ultimately offer, undoubtedly Wisconsin will not only be able to supply itself with iron, but to export it extensively to its neighbors.

The copper mines of Lake Superior I have not yet visited—they must be deferred to another season. But a range of country in the adjoining parts of Crawford and Bad Ax counties, and extending into Sauk county, on the Baraboo, in which copper ores have been found, has lately attracted renewed attention, and may prove of much importance. I have examined several localities in that district, this season, but further researches are necessary to speak with precision of their value.

I have ascertained, this season, I think satisfactorily, the existence of two shell beds, analagous in their fossils, as well as their lithological characters, to the shell beds in the upper part of the blue limestone. They are all particularly characterized by the abundance of shells of the genus *Leptæna*. The first occurs at the base of the blue shale, underlying the mound limestone, and thus immediately above the upper magnesian. It is as largely developed as the Bay settlement on the east shore of Green Bay, ten or twelve miles below the town of Green Bay, and at the iron mine, at Iron Ridge, Dodge county. It is marked in both localities by an abundance of branched corals. It occupies the same position in the strata as the fossiliferous layers called hard-pan, at the base of the blue shale of the mounds in the mining districts, but differs in its shells. The connexion of the two is formed by the corals, which are also found in the hard-pan. The other is found in the lower sandstone in the country on the Upper Mississippi, and has been regarded by Owen as the same with the shell bed of the blue limestone. It has appeared to me evident that its position is in the lower sandstone, at a higher level than a larger bed of limestone, regarded by Owen as the same with the lower magnesian. This subject will be farther discussed in its place in the report. If these three distinct beds, similar, at least generically in their fossils, but so remote in their position in the strata, shall be fully determined, as I doubt not, they will be, they will offer an interesting fact in fossil history. They will serve, too, as important land-marks in determining the strata less distinctly marked by fossils.

In my present report, I shall first complete my remarks on the mineral district, in the same order as in my last report. I there arranged the facts of most interest and importance under the general heads of stratification, mineral deposits, including the arrangements of the veins and openings in the different strata, and surface arrangement, in which the different diggings were particularly noticed. I shall pursue the same method in what remains to complete the survey of the mineral district. The facts which I have this year collected concur in general with those given in my last report, and add much strength to the views I then presented of the future prospects of mining in that district.

I shall then give the general result of my explorations of the state as far as I have now carried it. I shall first notice the rock formations, both primary and secondary.

I have had opportunity to observe the former class of rocks, only in a few detached localities, particularly at the falls of the northern rivers; still I have noticed the same tendency to grouping in local formations which I have pointed out in my report on the geology of Connecticut. Those rocks, as far as I have observed them in this state, have the most striking analogy to the primary rocks of New England, and if, as distinguished geologists suppose, the two are of remote periods, still the causes which have produced them both must have acted in a manner very nearly if not quite identical. Trap rocks have been noticed in former reports as occurring in different localities which I have visited, but I have not yet observed any rocks which correspond in arrangement, as well as character, with the trap rocks, which appear as intrusive in the midst of rocks of a very different character. The rocks known as trap, at the Falls of the St. Croix, and in the vicinity, are most nearly allied in character to such intrusive trap rocks, but in arrangement more nearly resemble the primary rocks, and might be regarded as approaching the primary greenstones. At the other localities visited, where trap rocks have been indicated, I have observed only hornblendic or sienitic rocks clearly belonging to the primary series. I have not yet seen sufficient reason to regard the primary rocks as metamorphic in their origin. But there are ranges of rocks in the state, in some instances extensive, which are apparently truly metamorphic in their character. That rock which is most obviously so, is a white compact quartz rock, strikingly resembling certain primary quartz rocks, and yet found in larger or smaller masses, as a constituent part of the sandstones, particularly in the lower, in the form either of horizontal beds or vertical dikes. The grey quartz rock, which forms mountain masses in the ridges adjoining the Baraboo valley, and in a tract east of Portland, and which includes minerals characteristic of the primary rocks, although less obviously connected with the sandstones, yet appears to have been really formed from them by metamorphic action. The quartz rocks near Black River, connected with beds of iron ore, has some appearance of a metamorphic rock, but is nearly vertical in position, like the primary rocks in the same district.

The reconnoissance which I have made this season, will enable me to give a general view of the stratification of the secondary rocks, and of the extent of surface occupied by each. The minute detail of the arrangement and distribution of these rocks, can only be obtained by long continued observation; but it is important that rallying points over the whole surface should be early established, so that the particular details may be collected and arranged as they occur, with more facility and a better degree of precision. Detached and remote observations, without such a connecting guide, may lead even experienced observers into error.

The metallic ores, included in the different rocks, both primary and secondary, as well as in the surface deposits, will next be noticed. Their characteristics, as well as their position in the rocks or elsewhere, will be detailed, and such remarks on their importance and economical application as have occurred to me, will be added. Attention will also be directed to the other mineral substances capable of useful application, whether in the arts or in agriculture. The occurrence of gypsum on the peninsula east of Green Bay, in Door county, is here worthy of particular notice.

The surface deposits will form an important section in this report, interesting both in a scientific and economical point of view. For the greater part of the surface traversed, is covered with loose materials; the rock formations occurring usually only in ravines and escarpments, or traversing the beds of rivers. These loose materials appear to have been deposited partly by a drift current acting over the whole surface, partly by local currents along valleys, and partly by sediment from still water, either over an extensive surface, or in limited basins. The boulder drift accumulated in hills and ridges over the general surface, where it prevails, is uniformly arranged so as to exhibit the action of extensive currents and eddies. A smaller drift of gravel and cobbles is found limited to the valleys of rivers, and appears to have been formed by the action of currents confined to such valleys. The former currents are analogous to those of an ocean; the latter to those of a strait. In the districts where surface is covered by the boulder drift, the surface conforms to the original drift surface, and has only been secondarily modified by washing. In those districts where the surface is covered by deposits from still water, the surface conforms to that produced by washing, and the degree of washing depends on the character of the subjacent rock, or the amount of exposure. Thus there is a greater degree of denudation where the subjacent rock is sandstone, or in the vicinity of valleys and out crops. The surface of the state, so far as I have traversed it, may be thus divided into two great districts, distinguished by the conformation of the surface, which may be called the Drift and Wash Districts; separated by a line drawn from the St. Croix, in Pierce county, in a general easterly direction, near the falls of the rivers, to the valley of the Wisconsin, and thence south by the head of the valley of Sugar river and Monroe, to the south line of the state near the Pecatonica. The country north and east of this line, belongs to the Drift District, that south and west of it, to the Wash District. This distinction is of importance in an agricultural point of view, the soils in the

Wash District being more closely connected with the subjacent rock than in the Drift District.

I have had in view during my reconnoisance this season, the general character of the soils of the different districts, and their connexion with vegetation. The relations of the different soils with vegetation, particularly with the growth of trees, is of great importance, and should be carefully noted. In this report I shall endeavor to point out the different classes of soils, so far as I have been able to distinguish them by observation, without analysis. Such a preliminary survey is important, in enabling the geologist to make a judicious selection of specimens for analysis, such as will be most extensively applicable to the whole agricultural interest. The state is of such extent, that all that is important cannot be effected at once. Time must be allowed to do all that is needful and desirable well. I trust I shall be excused if after having completed the examination of the Mineral District, which was first required by the act, I have been only able to make such a general reconnoisance as I have made through the more settled part of the state. Analyses of the different classes of soils as well as the different useful minerals, will properly form one of the concluding labors of the survey.

The formation of a cabinet—to be deposited in the state university—will also be one of the objects best attended to towards the close of the survey. Such a cabinet should be selected so as to exhibit most clearly and instructively all that is most important to the geology of the state both in a scientific and economical point of view. It is only when the whole ground is surveyed that the geologist can make his selections to the best advantage, and until then the specimens he may collect should justly be under his own care and keeping. I have constantly collected such specimens as I thought would best illustrate the different rocks and minerals in their different localities. Many of these will only serve a temporary purpose, to enable me to connect the different localities. Such as are proper to preserve with others collected for the purpose in those localities which are found best adapted to afford good illustrative specimens, may be combined to form the cabinet proposed.

The collections of fossils will be best effected by the aid of intelligent persons in the vicinity of excavations, such as mines or quarries, who will see that the specimens now and then collected shall be carefully preserved. I am happy to refer to the zealous labors of Mr. Hale, of Racine, in this pursuit, and hope that his example will be followed by many others, who will find in this employment of their leisure not only a high gratification, but that honorable fame which is so dear to us. I need not refer to the labors of Mr. Lapham in this department. They are known to all.

It may be thought by some that a geological survey can be best conducted by numerous local observers, who will each devote himself to the investigation of his vicinity. Such labors are of great importance in completing the details. But the advantage of a survey conducted by one person is the systematic unity which such can best give to the whole. It is only by personally inspecting numerous localities in every section of the state that the connection of the whole can be determined. When the general system is once well ascertained, the details, as they arise, can be adjusted, each in its appropriate place, and an order be established as useful in the common pursuits of life as it is interesting to the man of science. No one can flatter himself, with his best efforts, that he will not leave many things to be added or corrected by others; but an honest devotion to one's duties will doubtless be appreciated and rewarded.

The extent of the state, and the great number of important objects to be investigated, would only enable me, should I continue another year, to give an outline of a full survey. I would hope, for the best interest of the state, that the legislature will consent to the farther continuance of the survey. I do not suggest this from any personal consideration, but from a conviction that such an appropriation, well employed, will more than repay its cost.

Herewith I have the honor of submitting the following report:

Very respectfully,

JAMES G. PERCIVAL,

State Geologist.

REPORT.

THE MINERAL DISTRICT CONTINUED.

In my former report, I gave the result of my examination of the southern part of the mineral district. I have this season visited the more nothern diggings, and have thus completed the examination of the whole. These northern diggings are partly in the upper magnesian, but to a much greater extent than in the southern diggings, in the lower strata, particularly in the two upper beds of the blue limestone. The strata, in these more northern districts, conform very nearly, in their characters, to the same strata in the more southern districts. Such additional particulars, as have occurred to me in relation to them, may be first stated.

STRATIFICATION.

The effect of the general dip of the strata to the south, in elevating the lower strata, and thereby causing a denudation of the upper, is more obvious in these northern districts, than in the more southern. In approaching the Wisconsin river, the upper magnesian is reduced to its lowest portion, and even this is only found capping the highest points and ridges; the lower strata successively occupying a greater extent of the surface, till at last the lower magnesian forms a belt of some width along the Wisconsin, and the lower part of its principal branches.

The same inequalities in the strata, caused by detached points of elevation, may be also noticed here as in the southern districts. The diggings I have examined this season, are mostly on the northern border of some of the centres of elevation, noticed in my former report, viz, those on the east and west Pecatonica, and on Platte and Grant rivers; on the north or south side of the great divide between the Wisconsin and the streams flowing south to the Mississippi.

Facts observed by me this season seem to indicate that there are points of depression, as well as elevation, in the mineral district. The mounds apparently occupy such centres of depression; the strata dipping in toward them, at least from the north and south, and that at times quite abruptly. The northerly dip from the centre of elevation on Fever river, at Buzzard's Roost, towards the Platte Mounds, was noticed in my former report. A line of depression of the surface extends across the country from east to west, two to three miles north of those mounds, along the south side of which the strata are abruptly elevated, particularly at the south diggings, north of the east mound. A deep valley there extends west from the west fork of the west Pecatonica, on the south side of which the upper sandstone is raised to nearly the same elevation as the upper bed of the blue limestone on the north, and in the middle of which detached bluffs of the sandstone rise to an elevation of at least thirty feet above the sandstone on the north side of the valley, within a short distance. There would seem to have been, along this valley, a line of fracture, with an abrupt elevation of the strata on the south, accompained with a corresponding dip towards the east mound. The Blue Mounds are bordered on the north, at a short distance, by deep ravines, in which the upper sandstone rises to an elevation leaving little room for the strata interposed between it and the mound strata, if their position was horizontal; but which might be explained by a dip towards the mounds.

Some instances of a large dip from outcrops of the lower strata along valleys and ravines have occurred to me this season, marking a sudden elevation at these outcrops. Remarkable instances of this occur on the Mineral Point and Madison road, on the ascent south of the Dodgeville branch, where the upper sandstone dips largely (fifteen degrees) to the south; and at the Crow Branch diggings, where the dip is even greater than in the former instance, and has been traced by running a level from the outcrop of the upper sandstone into the opening in the lower part of the upper bed of the blue limestone (the pipe clay opening,) across the two lower beds of that rock. The irregular position of the upper sandstone in the breaks of the Wisconsin, or the country adjoining it on the south, intersected by deep valleys and ravines, indicates a similar disturbance of the stratification; that rock being found there, within short distances, at very different degrees of elevation. The two knobs north of Ridgeway are remarkable instances of this kind. I have not yet, however, made a sufficiently minute examination of that district to enter into farther details.

MOUND STRATA.

These I had examined last year in the Sinsinawa mound and the Platte mounds, and have noticed the particulars there observed in my former report. I have this season explored the Blue mounds, and have found there the same general arrangement as in the others, but the upper bed is there apparently wanting, and the middle bed, which in the other mounds is only a limestone, abounding in layers of flint or hornstone, is there composed of a mass of similar flint or hornstone, naturally white or light grey, but generally much stained, red, brown or yellow, by oxyd of iron. This flint contains frequent fossils analogous to those in the corresponding bed in the other mounds, particularly the *Pentamerus*. This remarkable anomaly, by which silex has almost if not quite replaced the limestone of the middle bed; appears peculiar to this locality. The middle bed in the Platte mounds abounds indeed in flint more than that in the mounds farther south and west, and that too, much resembling the flint of the Blue mounds, but in no other part of the country, where I have examined the mound strata, have I observed such an entire conversion of the middle bed to a siliceous mass. This flint bed is confined to the west mound; the east mound, which is much lower, being composed of the lower bed only. This lower bed is here composed of a very light grey, nearly compact limestone, in which fossils are much more rarely observed than in the same bed in the Sinsinawa mound, and closely resembles the corresponding bed in many localities in the overlying limestone on the east side of the state.

The underlying blue shale has been found at different points in the ravines near the base of the Blue Mounds, and in excavations in the same situation, but it has not been penetrated so far as to expose its junction with the upper magnesian and the fossiliferous layers found in that position. These layers are important in connecting the Mound limestones with the overlying limestones on the east side of the state. This connection has been already hinted at, and will hereafter be more particularly noticed in my general view of the stratification of the state.

UPPER MAGNESIAN.

This formation is less complete in the more northern districts than in the southern. The upper bed is clearly distinguished only near the mounds and in the higher dividing ridges; the surface where the upper magnesian is found, being to a much larger extent occupied by the flint or lower bed. The lower bed rarely shows the brown rock with its disseminated tiff (calc. spar) being usually marked only by the green rock, and the abundance of iron ore (iron pyrites, ochre and hematite), in the openings. The brown rock is well marked only in a series of diggings extending along a line south of Lancaster, between the Beetown diggings on the west, and the New California diggings on the east; including the Pigeon, Grab and Whitaker diggings. Although the middle part of the upper magnesian contains the largest proportion of flints, yet these are found more or less throughout its whole depth, particularly in its lower part, and mark its presence where only a thin cap of it is found on the ridges, towards the Wisconsin, occupied by the lower strata.

BLUE LIMESTONE.

This formation is much more exposed in the northern districts than in the more southern, and has been there more extensively excavated in mining, and thus offers there a much better opportunity of studying its arrangements. The divisions stated in my former report are there confirmed, and after the examination I have there made of them, can be laid down with more precision than in that report.

The upper bed may be divided into two distinct portions, an upper and a lower. The former is composed of thicker and more uniform layers, yet of a schistose structure, with blue marly seams, and disposed to separate into thinner layers by decomposition. It is sometimes, in its thicker layers, of a distinctly granular structure, like the upper magnesian, and is then subject to disintegrate like that rock, whence it is called sand rock in the more northern diggings. It is much less fossiliferous than the lower portion, and rarely contains any large openings; the mineral being usually found there in thin sheets, horizontal or vertical. This rock too, like the lower part of the upper magnesian, in some of the northern diggings, is sometimes stained green, particularly on its marly seams, by the hydrate of iron, and like that might be called the green rock. The lower portion consists of alternate layers of a harder and purer limestone, either compact or of a peculiar sparry structure, and of a soft bluish marl or shale, and abounds in fossils, forming the proper shell bed of the blue limestone. The most characteristic fossils of this shell-bed are of the genus *Leptæna*. The fossils are chiefly found in the limestone layers, which are sometimes mainly composed of them. The upper pipe clay opening is connected particularly with this lower portion.

The three divisions of the middle bed, noticed in my former report, are generally well characterized in the northern districts. The upper fine, granular portion, forms the cap of the proper glass-rock opening, and it is at the junction of this with the middle compact portion, that that opening is situated. This cap rock is peculiarly subject to a brown stain near that opening, and is hence called the brown rock by the miners. The compact portion forms the floor of the glass rock opening, and in the northern district is preferred for lime, and hence called *limestone*. The lower portion, consisting of thinner layers, with blue marly seams, and of a peculiar compact nodular structure, is usually divided into small jointed fragments. It is not considered proper for lime, but has been used in the manufacture of hydraulic cement, and is usually called *bastard limestone*. It is sometimes found forming a bed of unusual thickness, nearly replacing the middle compact portion. It abounds in fossils like the lower portion of the upper bed, but the most characteristic fossils of the latter are rarely found in it. The lower bed has presented nothing peculiar in the northern districts, nor has any productive opening been yet worked there in it.

LOWER MAGNESIAN.

This formation, in my former report, was divided into two beds, an upper and a lower; the latter characterized by a greater abundance of flint than the former. I then conjectured the existence of a third bed below the lower of those, corresponding in some degree to the upper bed in its character. My examination of the bluffs on the Mississippi and Wisconsin, near their junction, has confirmed this view. Three distinct beds are there observed; the upper and lower less marked by flint, but containing frequent geodes of chrystalized quartz, a character distinguishing the lower magnesian from the higher limestone strata; the middle marked numerous layers of flint, some of great thickness, particularly one near the upper surface of that bed, the position in which most of the mineral found in the lower magnesian has been discovered. Marly layers and seams, stained green by the hydrate of iron, [abound in connection with mineral in this position, as well as with that found in the upper bed.

The upper and lower sandstones not having yet been found productive of mineral, the consideration of them, as well as of the extent of surface occupied by the different strata, will be deferred to the general view of the geology of the state in a subsequent part of this report.

MINERAL DEPOSITS.

The mineral deposits in the more northern diggings are found in the same strata as in the more southern, as well as in the lower magnesian, but to a less extent in the upper magnesian. As the upper bed of the latter is there generally wanting, except in the vicinity of the mounds, or on the higher dividing ridges, the mineral is more generally found in the middle (flint,) and lower beds, extensive flat openings, like those in the two latter beds, noticed in my former report, such as those of Benton and Shullsburgh, are more rare, and the form most usually observed, in the northern diggings in the upper magnesian, is the kind of openings called tumbling openings, in which the mineral is distributed through the rock of the openings in bunches or pockets and veins; the latter forming connexions between the former, and intersecting the rock in various directions. These openings are so called from the circumstance that that part of the rock included between the more decomposed part of the rock accompanying the bunches and veins, retains nearly its original hardness. and forms loose and detached masses in the more decomposed rock of the openings. Usually the walls of such openings are well defined by vertical seams. Sometimes evenly, at other times more irregularly, the distinction between the softer and more decomposed mineral-bearing rock and the harder bounding rock being quite obvious. These tumbling openings are usually of a greater hight than the regular flat openings, and the mineral is arranged in them more in a vertical position. They are sometimes of much width, even twenty to thirty feet wide, and then appear as a combination of different veins, more or less connected, in the same general openings. The tendency of the mineral to form bunches is general in these openings. These openings usually continue in the same line or vertical plane, with occasional deviations or shiftings; but sometimes branches diverge from them, and in some instances, at a certain distance, take a course parallel to the main openings. These openings are generally east and west or quartering, but norths and souths are sometimes observed of a similar character, forming openings of several feet in width, with chunk mineral arranged in a manner conformable to that in east and west opening. Examples of these tumbling openings may be observed in the upper magnesian in most of the more northern diggings, as at the Blue Mounds, Dodgeville, Pedlar's Creek and Wingville. An example of a north and south of a similar character occurs in the brush range at Porter's Grove. These openings are of the same kind as those described in my former report, as occurring in the neighborhood of Mineral Point and in some of the more eastern diggings, as in those on the Yellowstone, in which the mineral is arranged in pockets or bunches, rather than in regular flat or vertical courses. The peculiar arrangement of the mineral, in these openings, in bunches rarely disposed in even courses, and often connected only by ochry seams, requires a greater degree of skill in working them where the mineral is more regularly arranged. In some instances diggings of this kind have been considered as worked out, which have afterwards yielded to miners, better skilled or more careful in following the slighter trace of connexion, an amount of mineral nearly or quite equal to that obtained by following the more obvious connexions.

Some of the most important ranges in the more northern diggings are formed of a combination of flat and pitching sheets, such as those described in my former report. These as I have there observed, have a greater downward range than other openings, extending with little interruption through different beds and even different formations. They appear in general to form two inclined sheets or courses, uniting at the summit in a common flat sheet, and dipping on either side of a middle bar, much less productive than the two lateral courses, if not quite barren. This middle bar has more or less of an opening character, being often intersected throughout with seams of iron pyrites, with the occasional occurrence of black jack or mineral; the latter sometimes occurring in veins or bunches of workable value. In some instances, the flat and pitching course is composed of only one sheet, but in others, several parallel sheets are combined in one opening ground, and even this difference may be observed in different parts of the same range. Such flat and pitching ranges sometimes are extended in the form of curves or horse shoes, and this arrangement, as far as I have observed, appears to be peculiar to these ranges. The Heathcock range (Linden) noticed in my former report, and the Lathrop range (Dodgeville) on which the engine of Washburn and Woodman is placed, are examples of such curvilinear ranges. The arrangement of sheets of mineral around a central mass or bar, in these ranges, has in some degree a parallel in some more regular east and west openings, in which a similar central mass of iron pyrites or pyritiferous rock forms, as it were, a core to the opening, on the sides of which the bunches and veins of mineral are deposited. Such a pyritiferous mass I have noticed in my former report, as traversing to a considerable extent the middle of the opening at Mr. A. Looney's level, (New Diggings,) and apparently cutting off the mineral. The level has been extended two or three hundred feet farther during the past year, and although the central mass has continued throughout, yet a large amount of mineral has been found adjoining it laterally, particularly on the north. I stated in my former report that the sheet on the south pitch at the west end of the Heathcock range had been traced a few feet into the upper bed of the blue limestone. It has since been followed down to a flat sheet resting on a pyritiferous mass apparently forming the base of a flat opening in the position of the upper pipe clay opening, and similar to the pyritiferous mass sometimes occupying the same position in the flat openings in the lower bed of the upper magnesian. The flat and pitching ranges just noticed, may either present a proper sheet arrangement, or a series of bunches ranged in a similar order; the mineral being, in the one case, more evenly distributed; in the other, more detached. The Heathcock range presents an example of the former arrangement, while the Lathrop range is more disposed to the latter. This last range, like the instances of such flat and pitching ranges, noticed in my former report, has been worked with little interruption from an early period, and is still productive. It was first struck in the upper part of the upper magnesian, and is not yet worked to much extent in the lower bed of that rock.

The greater part of the diggings in the Upper Magnesian, in the more northern districts, are in the lower bed of that rock, and from its great denudation often forms patches, or wide openings immediately beneath the surface deposits, from which the cap rock has been removed. The openings in this lower bed, in those districts, are more usually ochre or clay openings; the zinc or dry-bone openings generally occuring there in the blue limestone. The openings at Wingville are such ochre and clay openings; the ground being usually soft, and the mineral generally either in pockets or bunches, or more uniformly disseminated through the soft ground of the opening. In the former case, it is often large, and in more or less regular forms; sometimes forming geodes, or bosses of connected cubes around a projecting portion of the opening rock. In the latter case, it is usually quite small, and sometimes even, where abundantly disseminated, so small as to be obtained only by washing. Yet in these instances, it will be found, when observed in its original position, to be arranged in the same manner as the larger masses.

The brown rock of the lower bed of the upper magnesian is rarely found in the more northern diggings. Indeed it may be said to be found well characterized only in a range of diggings, already noticed, on an east and west line between the Beetown and New California diggings. In those it occurs in much the same manner as in the localities mentioned in my former report; not only with the peculiar chocolate-brown color of that rock, but more or less filled with disseminated tiff (calc. spar.) The openings in that rock, in those diggings, resemble too the wide flat openings in the same rock in the more southern diggings, but so far as I have observed are without zinc ores, and correspond rather to the ochre openings. The mineral in these wide, flat openings, is chiefly arranged in horizontal courses, one above and another below, but sometimes two in one, or both those positions, with occasional vertical veins or sheets intersecting them. The opening rock is generally much decomposed, and the mineral accompanied with sand or clay; but in some instances the rock is little altered, and so hard as to require blasting.

The opinion expressed in my former report, that the loose material found in the openings and investing the mineral have been very rarely introduced from without, but are the result of the decomposition of the opening rock and of the matrix of the mineral, has been confirmed this season by decisive facts, bearing directly upon it, as well as by the general result of my observations. The clay of the openings, in particular, is often found distinctly stratified, like a shale, and in following the same opening, it may be found to pass intc a hard state, occupying the opening in the same manner as the clay. An interesting example of this kind has recently occurred in the engine shaft at the Jamestown mine. The range is crossed about twenty feet west of the shaft by a cross crevice, west of which it has been very productive in the upper (vertical) opening. In sinking below this upper opening, the rock closed with an ochry mineral crevice passing down, and again opened, first in a small cave like opening, and then in a narrow vertical opening, occupied by a hard slate arranged in distinct horizontal layers, and bounded on each side by an ochry seam, like that traversing the close crevice above. This may be regarded as a matrix in a barren part of the range, and the same might be expected, in following it westward, beyond the cross crevice to the productive part of the range, to be found changed by decomposition to a soft slaty clay investing mineral. In boring from the bottom of the shaft, mineral has been lately struck at the depth of twenty feet, and followed down for eight feet, thus indicating that the same range may be barren in one of its openings and productive in another. This point will be farther considered in a subsequent paragraph. The sand too of the openings may often be traced, in the same range, into a hard limestone, and will be found stratified conformably to the latter. The passage of layers of flints through the soft sand and even the clay of the openings, scarcely at all disturbed in their arrangement, has often occurred to me. Those smooth rounded forms of the mineral found imbedded in soft materials, particularly in clay, which have been regarded by some as water worn, have been observed by me, in several instances, in the hard unaltered matrix, differing only in being less coated on the surface by the carbonate. Specimens of the same smooth rounded forms I have myself detached from an unaltered matrix of calcareous spar on the sulphate of barytes. That the mineral, with a few exceptions, where it is found on or near the surface, is in its original position and invested with its original matrix, only more or less altered by decomposition, appears to me without doubt.

North and south sheets, as well as those in other directions, are of frequent occurrence in the more northern diggings, and as in

The surface deposits will form an important section in this report, interesting both in a scientific and economical point of view. For the greater part of the surface traversed, is covered with loose materials; the rock formations occurring usually only in ravines and escarpments, or traversing the beds of rivers. These loose materials appear to have been deposited partly by a drift current acting over the whole surface, partly by local currents along valleys, and partly by sediment from still water, either over an extensive surface, or in limited basins. The boulder drifts accumulated in hills and ridges over the general surface, where it prevails, is uniformly arranged so as to exhibit the action of extensive currents and eddies. A smaller drift of gravel and cobbles is found limited to the valleys of rivers, and appears to have been formed by the action of currents confined to such valleys. The former currents are analogous to those of an ocean; the latter to those of a strait. In the districts where surface is covered by the boulder drift, the surface conforms to the original drift surface, and has only been secondarily modified by washing. In those districts where the surface is covered by deposits from still water, the surface conforms to that produced by washing, and the degree of washing depends on the character of the subjacent rock, or the amount of exposure. Thus there is a greater degree of denudation where the subjacent rock is sandstone, or in the vicinity of valleys and out crops. The surface of the state, so far as I have traversed it, may be thus divided into two great districts, distinguished by the conformation of the surface, which may be called the Drift and Wash Districts; separated by a line drawn from the St. Croix, in Pierce county, in a general easterly direction, near the falls of the rivers, to the valley of the Wisconsin, and thence south by the head of the valley of Sugar river and Monroe, to the south line of the state near the Pecatonica. The country north and east of this line, belongs to the Drift District; that south and west of it, to the Wash District. This distinction is of importance in an agricultural point of view, the soils in the

Wash District being more closely connected with the subjacent rock than in the Drift District.

I have had in view during my reconnoisance this season, the general character of the soils of the different districts, and their connexion with vegetation. The relations of the different soils with vegetation, particularly with the growth of trees, is of great importance, and should be carefully noted. In this report I shall endeavor to point out the different classes of soils, so far as I have been able to distinguish them by observation, without analysis. Such a preliminary survey is important, in enabling the geologist to make a judicious selection of specimens for analysis, such as will be most extensively applicable to the whole agricultural interest. The state is of such extent, that all that is important cannot be effected at once. Time must be allowed to do all that is needful and desirable well. I trust I shall be excused if after having completed the examination of the Mineral District, which was first required by the act, I have been only able to make such a general reconnoisance as I have made through the more settled part of the state. Analyses of the different classes of soils as well as the different useful minerals, will properly form one of the concluding labors of the survey.

The formation of a cabinet—to be deposited in the state university—will also be one of the objects best attended to towards the close of the survey. Such a cabinet should be selected so as to exhibit most clearly and instructively all that is most impertant to the geology of the state both in a scientific and economical point of view. It is only when the whole ground is surveyed that the geologist can make his selections to the best advantage, and until then the specimens he may collect should justly be under his own care and keeping. I have constantly collected such specimens as I thought would best illustrate the different rocks and minerals in their different localities. Many of these will only serve a temporary purpose, to enable me to connect the different localities. Such as are proper to preserve with others collected for the purpose in those localities which are found best adapted to afford good illustrative specimens, may be combined to form the cabinet proposed.

The collections of fossils will be best effected by the aid of intelligent persons in the vicinity of excavations, such as mines or quarries, who will see that the specimens now and then collected shall be carefully preserved. I am happy to refer to the zealous labors of Mr. Hale, of Racine, in this pursuit, and hope that his example will be followed by many others, who will find in this employment of their leisure not only a high gratification, but that honorable fame which is so dear to us. I need not refer to the labors of Mr. Lapham in this department. They are known to all.

It may be thought by some that a geological survey can be best conducted by numerous local observers, who will each devote himself to the investigation of his vicinity. Such labors are of great importance in completing the details. But the advantage of a survey conducted by one person is the systematic unity which such can best give to the whole. It is only by personally inspecting numerous localities in every section of the state that the connection of the whole can be determined. When the general system is once well ascertained, the details, as they arise, can be adjusted, each in its appropriate place, and an order be established as useful in the common pursuits of life as it is interesting to the man of science. No one can flatter himself, with his best efforts, that he will not leave many things to be added or corrected by others; but an honest devotion to one's duties will doubtless be appreciated and rewarded.

The extent of the state, and the great number of important objects to be investigated, would only enable me, should I continue another year, to give an outline of a full survey. I would hope, for the best interest of the state, that the legislature will consent to the farther continuance of the survey. I do not suggest this from any personal consideration, but from a conviction that such an appropriation, well employed, will more than repay its cost.

Herewith I have the honor of submitting the following report:

Very respectfully,

JAMES G. PERCIVAL,
State Geologist.

REPORT.

THE MINERAL DISTRICT CONTINUED.

In my former report, I gave the result of my examination of the southern part of the mineral district. I have this season visited the more nothern diggings, and have thus completed the examination of the whole. These northern diggings are partly in the upper magnesian, but to a much greater extent than in the southern diggings, in the lower strata, particularly in the two upper beds of the blue limestone. The strata, in these more northern districts, conform very nearly, in their characters, to the same strata in the more southern districts. Such additional particulars, as have occurred to me in relation to them, may be first stated.

STRATIFICATION.

The effect of the general dip of the strata to the south, in elevating the lower strata, and thereby causing a denudation of the upper, is more obvious in these northern districts, than in the more southern. In approaching the Wisconsin river, the upper magnesian is reduced to its lowest portion, and even this is only found capping the highest points and ridges; the lower strata successively occupying a greater extent of the surface, till at last the lower magnesian forms a belt of some width along the Wisconsin, and the lower part of its principal branches.

The same inequalities in the strata, caused by detached points of elevation, may be also noticed here as in the southern districts. The diggings I have examined this season, are mostly on the northern border of some of the centres of elevation, noticed in my former report, viz., those on the east and west Pecatonica, and on Platte and Grant rivers; on the north or south side of the great divide between the Wisconsin and the streams flowing south to the Mississippi.

Facts observed by me this season seem to indicate that there are points of depression, as well as elevation, in the mineral district. The mounds apparently occupy such centres of depression; the strata dipping in toward them, at least from the north and south, and that at times quite abruptly. The northerly dip from the centre of elevation on Fever river, at Buzzard's Roost, towards the Platte Mounds, was noticed in my former report. A line of depression of the surface extends across the country from east to west, two to three miles north of those mounds, along the south side of which the strata are abruptly elevated, particularly at the south diggings, north of the east mound. A deep valley there extends west from the west fork of the west Pecatonica, on the south side of which the upper sandstone is raised to nearly the same elevation as the upper bed of the blue limestone on the north, and in the middle of which detached bluffs of the sandstone rise to an elevation of at least thirty feet above the sandstone on the north side of the valley, within a short distance. There would seem to have been, along this valley, a line of fracture, with an abrupt elevation of the strata on the south, accompained with a corresponding dip towards the east mound. The Blue Mounds are bordered on the north, at a short distance, by deep ravines, in which the upper sandstone rises to an elevation leaving little room for the strata interposed between it and the mound strata, if their position was horizontal, but which might be explained by a dip towards the mounds.

Some instances of a large dip from outcrops of the lower strata along valleys and ravines have occurred to me this season, marking a sudden elevation at these outcrops. Remarkable instances of this occur on the Mineral Point and Madison road, on the ascent south of the Dodgeville branch, where the upper sandstone dips largely (fifteen degrees) to the south; and at the Crow Branch diggings, where the dip is even greater than in the former instance, and has been traced by running a level from the outcrop of the upper sandstone into the opening in the lower part of the upper bed of the blue limestone (the pipe clay opening;) across the two lower beds of that rock. The irregular position of the upper sandstone in the breaks of the Wisconsin, or the country adjoining it on the south, intersected by deep valleys and ravines, indicates a similar disturbance of the stratification; that rock being found there, within short distances, at very different degrees of elevation. The two knobs north of Ridgeway are remarkable instances of this kind. I have not yet, however, made a sufficiently minute examination of that district to enter into farther details.

MOUND STRATA.

These I had examined last year in the Sinsinawa mound and the Platte mounds, and have noticed the particulars there observed in my former report. I have this season explored the Blue mounds, and have found there the same general arrangement as in the others, but the upper bed is there apparently wanting, and the middle bed, which in the other mounds is only a limestone, abounding in layers of flint or hornstone, is there composed of a mass of similar flint or hornstone, naturally white or light grey, but generally much stained, red, brown or yellow, by oxyd of iron. This flint contains frequent fossils analogous to those in the corresponding bed in the other mounds, particularly the *Pentamerus*. This remarkable anomaly, by which silex has almost if not quite replaced the limestone of the middle bed, appears peculiar to this locality. The middle bed in the Platte mounds abounds indeed in flint more than that in the mounds farther south and west, and that too, much resembling the flint of the Blue mounds, but in no other part of the country, where I have examined the mound strata, have I observed such an entire conversion of the middle bed to a siliceous mass. This flint bed is confined to the west mound; the east mound, which is much lower, being composed of the lower bed only. This lower bed is here composed of a very light grey, nearly compact limestone, in which fossils are much more rarely observed than in the same bed in the Sinsinawa mound, and closely resembles the corresponding bed in many localities in the overlying limestone on the east side of the state.

The underlying blue shale has been found at different points in the ravines near the base of the Blue Mounds, and in excavations in the same situation, but it has not been penetrated so far as to expose its junction with the upper magnesian and the fossiliferous layers found in that position. These layers are important in connecting the Mound limestones with the overlying limestones on the east side of the state. This connection has been already hinted at, and will hereafter be more particularly noticed in my general view of the stratification of the state.

UPPER MAGNESIAN.

This formation is less complete in the more northern districts than in the southern. The upper bed is clearly distinguished only near the mounds and in the higher dividing ridges; the surface where the upper magnesian is found, being to a much larger extent occupied by the flint or lower bed. The lower bed rarely shows the brown rock with its disseminated tiff (calc. spar) being usually marked only by the green rock, and the abundance of iron ore (iron pyrites, ochre and hematite), in the openings. The brown rock is well marked only in a series of diggings extending along a line south of Lancaster, between the Beetown diggings on the west, and the New California diggings on the east, including the Pigeon, Grab and Whitaker diggings. Although the middle part of the upper magnesian contains the largest proportion of flints, yet these are found more or less throughout its whole depth, particularly in its lower part, and mark its presence where only a thin cap of it is found on the ridges, towards the Wisconsin, occupied by the lower strata.

BLUE LIMESTONE.

This formation is much more exposed in the northern districts than in the more southern, and has been there more extensively excavated in mining, and thus offers there a much better opportunity of studying its arrangements. The divisions stated in my former report are there confirmed, and after the examination I have there made of them, can be laid down with more precision than in that report.

The upper bed may be divided into two distinct portions, an upper and a lower. The former is composed of thicker and more uniform layers, yet of a schistose structure, with blue marly seams, and disposed to separate into thinner layers by decomposition. It is sometimes, in its thicker layers, of a distinctly granular structure, like the upper magnesian, and is then subject to disintegrate like that rock, whence it is called sand rock in the more northern diggings. It is much less fossiliferous than the lower portion, and rarely contains any large openings; the mineral being usually found there in thin sheets, horizontal or vertical. This rock too, like the lower part of the upper magnesian, in some of the northern diggings, is sometimes stained green, particularly on its marly seams, by the hydrate of iron, and like that might be called the green rock. The lower portion consists of alternate layers of a harder and purer limestone, either compact or of a peculiar sparry structure, and of a soft bluish marl or shale, and abounds in fossils, forming the proper shell bed of the blue limestone. The most characteristic fossils of this shell-bed are of the genus *Leptæna.* The fossils are chiefly found in the limestone layers, which are sometimes mainly composed of them. The upper pipe clay opening is connected particularly with this lower portion.

The three divisions of the middle bed, noticed in my former report, are generally well characterized in the northern districts. The upper fine, granular portion, forms the cap of the proper glass-rock opening, and it is at the junction of this with the middle compact portion, that that opening is situated. This cap rock is peculiarly subject to a brown stain near that opening, and is hence called the brown rock by the miners. The compact portion forms the floor of the glass rock opening, and in the northern district is preferred for lime, and hence called *limestone.* The lower portion, consisting of thinner layers, with blue marly seams, and of a peculiar compact nodular structure, is usually divided into small jointed fragments. It is not considered proper for lime, but has been used in the manufacture of hydraulic cement, and is usually called *bastard limestone.* It is sometimes found forming a bed of unusual thickness, nearly replacing the middle compact portion. It abounds in fossils like the lower portion of the upper bed, but the most characteristic fossils of the latter are rarely found in it. The lower bed has presented nothing peculiar in the northern districts, nor has any productive opening been yet worked there in it.

LOWER MAGNESIAN.

This formation, in my former report, was divided into two beds, an upper and a lower; the latter characterized by a greater abundance of flint than the former. I then conjectured the existence of a third bed below the lower of those, corresponding in some degree to the upper bed in its character. My examination of the bluffs on the Mississippi and Wisconsin, near their junction, has confirmed this view. Three distinct beds are there observed; the upper and lower less marked by flint, but containing frequent geodes of chrystallized quartz, a character distinguishing the lower magnesian from the higher limestone strata; the middle marked numerous layers of flint, some of great thickness, particularly one near the upper surface of that bed, the position in which most of the mineral found in the lower magnesian has been discovered. Marly layers and seams, stained green by the hydrate of iron, abound in connection with mineral in this position, as well as with that found in the upper bed.

The upper and lower sandstones not having yet been found productive of mineral, the consideration of them, as well as of the extent of surface occupied by the different strata, will be deferred to the general view of the geology of the state in a subsequent part of this report.

MINERAL DEPOSITS.

The mineral deposits in the more northern diggings are found in the same strata as in the more southern, as well as in the lower magnesian, but to a less extent in the upper magnesian. As the upper bed of the latter is there generally wanting, except in the vicinity of the mounds, or on the higher dividing ridges, the mineral is more generally found in the middle (flint,) and lower beds, extensive flat openings, like those in the two latter beds, noticed in my former report, such as those of Benton and Shullsburgh, are more rare, and the form most usually observed, in the northern diggings in the upper magnesian, is the kind of openings called tumbling openings, in which the mineral is distributed through the rock of the openings in bunches or pockets and veins; the latter forming connexions between the former, and intersecting the rock in various directions. These openings are so called from the circumstance that that part of the rock included between the more decomposed part of the rock accompanying the bunches and veins, retains nearly its original hardness. and forms loose and detached masses in the more decomposed rock of the openings. Usually the walls of such openings are well defined by vertical seams. Sometimes evenly, at other times more irregularly, the distinction between the softer and more decomposed mineral-bearing rock and the harder bounding rock being quite obvious. These tumbling openings are usually of a greater hight than the regular flat openings, and the mineral is arranged in them more in a vertical position. They are sometimes of much width, even twenty to thirty feet wide, and then appear as a combination of different veins, more or less connected, in the same general openings. The tendency of the mineral to form bunches is general in these openings. These openings usually continue in the same line or vertical plane, with occasional deviations or shiftings; but sometimes branches diverge from them, and in some instances, at a certain distance, take a course parallel to the main openings. These openings are generally east and west or quartering, but norths and souths are sometimes observed of a similar character, forming openings of several feet in width, with chunk mineral arranged in a manner conformable to that in east and west opening. Examples of these tumbling openings may be observed in the upper magnesian in most of the more northern diggings, as at the Blue Mounds, Dodgeville, Pedlar's Creek and Wingville. An example of a north and south of a similar character occurs in the brush range at Porter's Grove. These openings are of the same kind as those described in my former report, as occurring in the neighborhood of Mineral Point and in some of the more eastern diggings, as in those on the Yellowstone, in which the mineral is arranged in pockets or bunches, rather than in regular flat or vertical courses. The peculiar arrangement of the mineral, in these openings, in bunches rarely disposed in even courses, and often connected only by ochry seams, requires a greater degree of skill in working them where the mineral is more regularly arranged. In some instances diggings of this kind have been considered as worked out, which have afterwards yielded to miners, better skilled or more careful in following the slighter trace of connexion, an amount of mineral nearly or quite equal to that obtained by following the more obvious connexions.

Some of the most important ranges in the more northern diggings are formed of a combination of flat and pitching sheets, such as those described in my former report. These as I have there observed, have a greater downward range than other openings, extending with little interruption through different beds and even different formations. They appear in general to form two inclined sheets or courses, uniting at the summit in a common flat sheet, and dipping on either side of a middle bar, much less productive than the two lateral courses, if not quite barren. This middle bar has more or less of an opening character, being often intersected throughout with seams of iron pyrites, with the occasional occurrence of black jack or mineral; the latter sometimes occurring in veins or bunches of workable value. In some instances, the flat and pitching course is composed of only one sheet, but in others, several parallel sheets are combined in one opening ground, and even this difference may be observed in different parts of the same range. Such flat and pitching ranges sometimes are extended in the form of curves or horse shoes, and this arrangement, as far as I have observed, appears to be peculiar to these ranges. The Heathcock range (Linden) noticed in my former report, and the Lathrop range (Dodgeville) on which the engine of Washburn and Woodman is placed, are examples of such curvilinear ranges. The arrangement of sheets of mineral around a central mass or bar, in these ranges, has in some degree a parallel in some more regular east and west openings, in which a similar central mass of iron pyrites or pyritiferous rock forms, as it were, a core to the opening, on the sides of which the bunches and veins of mineral are deposited. Such a pyritiferous mass I have noticed in my former report, as traversing to a considerable extent the middle of the opening at Mr. A. Looney's level, (New Diggings,) and apparently cutting off the mineral. The level has been extended two or three hundred feet farther during the past year, and although the central mass has continued throughout, yet a large amount of mineral has been found adjoining it laterally, particularly on the north. I stated in my former report that the sheet on the south pitch at the west end of the Heathcock range had been traced a few feet into the upper bed of the blue limestone. It has since been followed down to a flat sheet resting on a pyritiferous mass apparently forming the base of a flat opening in the position of the upper pipe clay opening, and similar to the pyritiferous mass sometimes occupying the same position in the flat openings in the lower bed of the upper magnesian. The flat and pitching ranges just noticed, may either present a proper sheet arrangement, or a series of bunches ranged in a similar order; the mineral being, in the one case, more evenly distributed; in the other, more detached. The Heathcock range presents an example of the former arrangement, while the Lathrop range is more disposed to the latter. This last range, like the instances of such flat and pitching ranges, noticed in my former report, has been worked with little interruption from an early period, and is still productive. It was first struck in the upper part of the upper magnesian, and is not yet worked to much extent in the lower bed of that rock.

The greater part of the diggings in the Upper Magnesian, in the more northern districts, are in the lower bed of that rock, and from its great denudation often forms patches, or wide openings immediately beneath the surface deposits, from which the cap rock has been removed. The openings in this lower bed, in those districts, are more usually ochre or clay openings; the zinc or dry-bone openings generally occuring there in the blue limestone. The openings at Wingville are such ochre and clay openings; the ground being usually soft; and the mineral generally either in pockets or bunches, or more uniformly disseminated through the soft ground of the opening. In the former case, it is often large, and in more or less regular forms; sometimes forming geodes, or bosses of connected cubes around a projecting portion of the opening rock. In the latter case, it is usually quite small, and sometimes even, where abundantly disseminated, so small as to be obtained only by washing. Yet in these instances, it will be found, when observed in its original position, to be arranged in the same manner as the larger masses.

The brown rock of the lower bed of the upper magnesian, is rarely found in the more northern diggings. Indeed it may be said to be found well characterized only in a range of diggings, already noticed, on an east and west line between the Beetown and New California diggings. In those it occurs in much the same manner as in the localities mentioned in my former report; not only with the peculiar chocolate-brown color of that rock, but more or less filled with disseminated tiff (calc. spar.) The openings in that rock, in those diggings, resemble too the wide flat openings in the same rock in the more southern diggings, but so far as I have observed are without zinc ores, and correspond rather to the ochre openings. The mineral in these wide, flat openings, is chiefly arranged in horizontal courses, one above and another below, but sometimes two in one, or both those positions, with occasional vertical veins or sheets intersecting them. The opening rock is generally much decomposed, and the mineral accompanied with sand or clay; but in some instances the rock is little altered, and so hard as to require blasting.

The opinion expressed in my former report, that the loose material found in the openings and investing the mineral have been very rarely introduced from without, but are the result of the decomposition of the opening rock and of the matrix of the mineral, has been confirmed this season by decisive facts, bearing directly upon it, as well as by the general result of my observations. The clay of the openings, in particular, is often found distinctly stratified, like a shale, and in following the same opening, it may be found to pass into a hard state, occupying the opening in the same manner as the clay. An interesting example of this kind has recently occurred in the engine shaft at the Jamestown mine. The range is crossed about twenty feet west of the shaft by a cross crevice, west of which it has been very productive in the upper (vertical) opening. In sinking below this upper opening, the rock closed with an ochry mineral crevice passing down, and again opened, first in a small cave like opening, and then in a narrow vertical opening, occupied by a hard slate arranged in distinct horizontal layers, and bounded on each side by an ochry seam, like that traversing the close crevice above. This may be regarded as a matrix in a barren part of the range, and the same might be expected, in following it westward, beyond the cross crevice to the productive part of the range, to be found changed by decomposition to a soft slaty clay investing mineral. In boring from the bottom of the shaft, mineral has been lately struck at the depth of twenty feet, and followed down for eight feet, thus indicating that the same range may be barren in one of its openings and productive in another. This point will be farther considered in a subsequent paragraph. The sand too of the openings may often be traced, in the same range, into a hard limestone, and will be found stratified conformably to the latter. The passage of layers of flints through the soft sand and even the clay of the openings, scarcely at all disturbed in their arrangement, has often occurred to me. Those smooth rounded forms of the mineral, found imbedded in soft materials, particularly in clay, which have been regarded by some as water-worn, have been observed by me, in several instances, in the hard unaltered matrix, differing only in being less coated on the surface by the carbonate. Specimens of the same smooth rounded forms I have myself detached from an unaltered matrix of calcarous spar on the sulphate of barytes. That the mineral, with a few exceptions, where it is found on or near the surface, is in its original position and invested with its original matrix, only more or less altered by decomposition, appears to me without doubt.

North and south sheets, as well as those in other directions, are of frequent occurrence in the more northern diggings, and as in dinate lines. The diggings along the divide and on the upper part of the west fork are in the upper magnesian; those along the lower part of the west fork, in the blue limestone. The first subordinate line commences in the Burying Ground diggings, on a ridge between two small branches of the little Platte adjoining the divide on the west, and consists of a long series of only two main parallel ranges first bearing E. N. E. and then north by east, shifting to the west near the middle of the latter part of their course. The mineral is in the form of sheets closely wedged in the rock, or in crevices with ochry clay. In a line north east from these diggings, is a large and productive east and west range, (Ludd's,) forming a wide opening apparently in the flint bed of the upper magnesian, east of which is a group of north and south sheet ranges. The bearing of the east and west is E. S. E.; that of the north and souths, north by west. North of this group is another detached group of north and souths, terminating this line on the north.

Another subordinate line may be traced along the divide commencing in a group of diggings south west of Blackjack, composed chiefly of east and wests, bearing both E. S. E. and E. N. E., and crossed by a number of north and souths on the west. W. N. W. of Black Jack is an extensive group of sheet ranges, generally bearing N. N. E., but sometimes E. S. E. or even shifting their course so as to present a curvilinear arrangement. These sheets are generally accompanied with ochre or iron pyrites, and in one instance with black jack, and are apparently in the middle or lower part of the upper magnesian, according to the elevation of the surface. In a line north by east of these diggings, and east of the north group in the first line, is a large detached group (the Tail holt diggings), consisting chiefly of east and wests, forming regular openings or wide patches, crossed by a few north and souths, particularly along the west side of the group. A third subordinate line may be traced along the west fork and the east side of its east branch, in a direction nearly north and south.

This includes first the south diggings (on the west side of the west fork and on the north side of the remarkable east and west valley marked by an extraordinary elevation of the lower strata, already noticed,) consisting of a group of ranges of glass-rock openings bearing N. by W., the two western ranges crossed on the south by a body of heavy spar investing the mineral. North of this are the black jack diggings, among the most important in the mineral district, consisting of three main ranges, already noticed, bearing south-easterly, and terminating in the bluff on the west side of the west fork. These are in the main opening in the upper bed of the blue limestone, and are particularly remarkable for the great quantity of zinc ore in the openings. On the east side of the west fork, just north, are a few unimportant east and west ranges worked in the lower part of the upper magnesian, and extending down into the blue limestone. This line is continued up the east side of the east branch of the west fork by a few ranges of little importance, to the Madden range, a large east and west range nearly east of the Tail-holt diggings. These diggings on the east branch are all in the upper magnesian.

The second line bearing north and north east (13), including the Lost Grove and Pedlar's Creek diggings, extends from a point east of the south diggings, above noticed, up both sides of Pedlar's Creek to the Military road on the divide between the Pecatonica and the Wisconsin. It commences in a large east and west range in an ochre opening in the upper magnesian, on the divide between the west fork and Pedlar's Creek, north east of which a line of diggings in the blue limestone extends along the west side of Pedlar's Creek, generally in the glass rock opening, but in a few instances in the main opening in the upper bed. The ranges generally bear east and west, but in a few instances in the opening in the upper bed, north by west. Nearly opposite these diggings, on the east side of Pedlar's Creek, are the Lost Grove diggings. These are partly in the lower bed of the upper magnesian, on the highest parts of the ridges, and partly in the blue limestone, on the sides of the ridges towards the ravines. The productive ranges in the blue limestone are all in the glass-rock opening, the upper opening being found here of little importance. This group presents on the north, on the north side of a ravine leading west, a long east and west range in the upper magnesian, on the higher ground, and two parallel east and west ranges, lower on the descent and further east, already noticed; the northern, a sulphur range towards the west, and a black-jack range towards the east; the southern, a clay range. On the summit of the ridge south of the ravine, is a large patch in the upper magnesian apparently formed by a wide east and west, crossed towards the west by a similar north and south. On the south side of this ridge, is a large range in the glass-rock opening, in which the mineral is accompanied with tiff and clay, bearing south by east. Other less important ranges occur in this group, both in the upper magnesian and blue limestone. Farther north in the bluff, on the west side of Pedlar's Creek, copper ore (similar to that of Mineral Point) has been discovered in the main opening on the upper bed of the blue limestone, but has not been worked to any extent. Nearly opposite, on the side of the ridge east, is a single vertical sheet range, bearing E. S. E., (the Black Hawk diggings,) and nearly in the same line towards the creek, a range worked to a small extent in the upper bed of the blue limestone. North by west of these, the Pedlar's Creek diggings extend in an almost continuous series from a point nearly west of Linden village to the divide at the Military road already mentioned. They commenced farthest south on the west side of the creek, at an east and west, (the Whym range,) from which extends a line of north and souths, (the Provision lot,) nearly east of which is the Heathcock range, the most southern on the east, and the most important in the whole group.

This last forms a curve, convex to the N. east, and opposite its west end, a line of north and souths extend along the west side of the creek, and then apparently crosses to the east, and is continued in a line of east and wests slightly convex to the north. Throughout this whole extent zinc ores are more or less abundant, while i the other ranges of the group they are rarely met with. From thi apparently connected range, lines of north and souths exten along both sides of the creek to a point north of the Frankli road, crossed in a few points by east and wests, particularly a Covel's diggings, in a line nearly east of the Madden range. A the point north of the Franklin road, above mentioned, there is small group of east and wests, from which the main line of the diggings recedes east to a line of north and souths, which continue more interruptedly to the divide north of the Military road. Th diggings throughout this whole group are in the upper magnesian except at Ross' range, in the line of north and souths, east of th creek, not far north of the dry-bone range connected with th Heathcock range. An opening has there been reached in th blue limestone in the lower part of the upper bed, in which th mineral is imbedded in a soft blue clay. The north and south form sheet ranges. In the Heathcock range and its connexions the mineral is arranged in flat and pitching sheets, generally accompained with zinc ores. The east and wests, particularly a Covel's, form large ochre and clay openings, sometimes abounding in iron pyrites and hematite, (the latter from the decomposition of the former.) A few scattered diggings, are found in th prairies north west as far as Cross Plains, at the crossing of th Franklin and Millitary roads.

A line of diggings parallel to the former may be traced fro Diamond Grove, west of Mineral Point, on the ridge west of th east fork of the West Pecatonica, to a point north of the Militar road. This commences in a large north and south range (Thrasher's) in the lower part of the upper magnesian. Farther north beyond a deep ravine, is a group of east and wests, in the sam part of the upper magnesian, generally in ochre and clay openings, sometimes forming patches at the surface, from which th cap has been removed. North by west from these, are too smal groups of diggings in the blue limestone on opposite sides of the east fork of Pedlar's Creek. Those on the west are in the glass-rock opening; those on the east in the same opening towards the south, and in the opening in the upper bed towards the north. Still north by west, on the ridge west of the fork, is a detached east and west range, crossed and shifted to the north, in its middle part, by north and souths, from which a line of remotely detached north and souths extends to the military road, terminating in a larger group of ranges (the Pump Diggings) bearing around from N. N. E. to E. N. E. These diggings, west of the east fork of Pedlar's Creek, are all in the upper magnesian, north of the Military road, and N. W. of the Pump diggings, is a wide east and west range (Black Davy's,) on a ridge between two ravines leading to the Wisconsin. This range is in the lower part of the upper magnesian, in a rock with green seams and but little flint, resembling the green rock of Mineral Point; and the mineral is either in sheets in the hard rock, or in soft sand or ochre openings. The Otter Creek diggings at the east end of series 11, are N. W. from this point.

From the Dreadnaught range, at the north end of the Mineral Point diggings, as represented in my former report, a series of diggings extends northerly, by Van Meter's survey, to the S. W. point of the Dodgeville diggings. None of these are important, except two large east and wests at the survey. They are all in the upper magnesian, and east and wests till we reach the northern diggings at the survey, whence a line of north and souths extends along the west side of the Dodgeville diggings.

The line of diggings (14) bearing easterly along the divide between the Wisconsin and the Pecatonica, from the Dodgeville to the Blue Mound diggings inclusive, may be considered as terminating the great series continued from series 1, unless it be extended south-easterly to the Sugar-river diggings at or near Exeter, as suggested in my former report. The diggings in this line are mostly on the south slope divide, but in a few instances pass north between the ravines leading to the Wisconsin. The Dodgeville diggings commence on the west, in the line of north and souths above indicated, which bears N. N. E. by a series of shifts to the east, to a ridge between ravines leading to the Wisconsin. Another line of north and souths commences on the west of the Lathrop range, at Dodgeville village, and inclines to the west, till it unites with the former towards its northern extremity. This last line is quite uninterrupted in its southern half, and is there crossed on the north and south by east and wests, those on the south connected with the south part of the Lathrop range. This last, the most important in these diggings, forms a curve or horse-shoe, first bearing north by west, and then north easterly across a ravine at Washburne's engine. A group of sheet ranges bears north by west, parallel to the south part of the Lathrop range on the east, and apparently crosses the north-east part of the latter. The Dodgeville diggings, thus far, are all in the upper magnesian, commencing on the higher grounds in the upper bed, and extending in the ravines to the lower, but chiefly in the middle flint bed, particularly in the southern east and wests and the Lathrop range. The north and souths are all sheets, usually closely wedged in hard rock; the east and wests as well as the Lathrop range, present tumbling openings, which in the latter are arranged in pitches on each side of a middle less productive bar. Farther east a line of diggings in the blue limestone extends north-easterly from a point about a mile east of Dodgeville to the Holyhead diggings. These are all on the sides of the ravines of different branches which unite to form the Dodgeville branch of the East Pecatonica. They are all apparently in the glass-rock opening, the upper opening not having been found productive. The mineral is generally accompanied with zinc ores, but sometimes with iron or clay. The bearing of the ranges is usually south-east, but varies from S. S. E. to E. S. E. presenting remarkable irregularities in their course. North of the Holyhead diggings, is a group of diggings, at Mercersburg, chiefly in the lower part of the upper magnesian. Towards the south, on the ridge west of the Holyhead branch, is a large patch bearing north and south, presenting a flat sheet in the upper magnesian, intersected by a number of north and south vertical sheets. A shaft has been sunk there to a pipe clay opening with square mineral, in the upper bed of the blue limestone. Farther north is a group of north and south sheets in the lower bed of the upper magnesian. This is continued, with some interruptions, to the summit of the divide towards the Wisconsin, crossing a considerable east and west range in its course. On the summit, a ridge east of the south part of the diggings in the blue limestone, are the Norway diggings, a group of east and wests in the upper magnesian. East of these, on the high grounds east of the Holyhead branch, is another large group in the upper magnesian. Those towards the west are mostly east and wests, first bearing E. S. E. and then E. N. E., and are crossed towards the east by a large group of north and souths bearing N. N. W.

Not far east of the group last noticed the Porter's Grove diggings form a considerable group, chiefly on the south of the divide, but extending across it towards the Wisconsin. These diggings are chiefly north and souths, crossed towards the south by a large east and west (the Wakefield range.) There are two large north and souths, (the Firm and Brush leads), the last of which has been followed about two miles, extending far across the divide, and terminating in a flat opening with dice mineral, in the upper bed of the blue limestone. The north and souths carry sheets, except the Brush range, which at the divide forms a wide opening with chunk mineral. These diggings are in the upper magnesian with the exception above noticed. Scattered diggings occur along the south side of the divide between the Porter's Grove and Blue Mound diggings, but none are of interest except a line extending north by east along a ridge about half-way between them. These diggings are apparently in the lower part of the upper magnesian, and are chiefly patches or wide ochre and clay openings near the surface. They commence on the south west at O'Neil's diggings, and extend at intervals about two miles to the military road.

The Blue Mound diggings form a number of distinct groups, south of the Blue Mounds, and are also in the upper magnesian, generally in the flint bed, although in a few instances, at the ravines, mineral has been traced into the blue limestone. The ranges are almost invariably east and west, bearing about east ten degrees south, and usually present wide tumbling openings, which at the ravines, particularly in the more southern ranges, are uncapped, forming patches near the surface. The principal group is at Brigham's range, a large and productive east and west, north of which is another considerable range on which an engine has been recently placed. Dudley's range, south west from this group, is a large detached east and west, and two large east and wests occur at Hawthorn's diggings on the south. Hyde's range, more remote to the S. S. W., is another large range bearing E. S. E. by a series of shifts to the south, the parts of the range having the usual bearing above noticed. A number of less important diggings extend E. S. E. from Brigham's range, about five miles, to Shaw's diggings, a small group of east and wests in the lower part of the upper magnesian. This point is the most remote in the series, unless we include the Sugar River diggings towards the S. E.

Returning west, the series 11, may be traced from its S. W. point towards the N. E. and E. It commences, in this state, in a high bluff on the east side of the Mississippi, at Roy's Landing, S. W. of which are the Guttenberg diggings, on the opposite bank, in a similar situation. This bluff forms a narrow ridge overlaid by a thick bed of the upper magnesian, forming an abrupt wall on the west, below which is a steep slope occupied by the blue limestone and upper sandstone, extending to a low terrace of the lower magnesian at the water's edge. This ridge is apparently traversed by an east and west range, in the flint bed of the upper magnesian, crossed on the east side by a north and south crevice;

more productive even than the east and west. The opening is occupied by sand and clay, with much tiff in large masses or disseminated. Small quantities of mineral have been found in the upper part of the lower magnesian, near the Mississippi, one or two miles farther north.

Proceeding north east, we arrive, after a long interval, at the Fenimore diggings, in a line west of Wingville, on the divide between Grant river and the Wisconsin. They consist of two small groups, about two miles apart; one north-west, on the north side of the divide, consisting of two east and wests, the other farther east of one large east and west, by the military road, and others smaller on the north. They are in clay and ochre openings, in a rock with flint, but apparently the lower part of the upper magnesian, and in character resemble the Wingville diggings.

Proceeding east along the divide, by the military road, we arrive at the Wingville diggings, the first of importance in this series. The main body of the diggings crosses the divide east of Wingville village, and extends nearly twice as far from north to south as from east to west. This corresponds with their position in the transverse series extending from the Platteville to the Centerville diggings, already noticed. They are in ochre and clay openings, in a sandy rock with flint, apparently the lower part of the upper magnesian. The ranges are all east and wests, varying from E. N. E. to E. S. E. Black jack has been found here only in two remote points on the west.

Shifting to the north across the valley of Blue river, the series is continued in the Centerville diggings. These are all situated in the main opening in the upper bed of the blue limestone, except in one instance, already noticed, where a lower opening, apparently corresponding to the glass rock opening, has been reached at a short distance below the main opening. They extend from west to east along the ridge immediately north of Blue river, and presents three distinct groups, two west and one east of the village. The ground is these groups is nearly underlaid by contiguous wide flat openings, the apparent direction of which is south-easterly, but by successive shifts to the north, in proceeding east, the bearing of the groups varies from E. N. E. so north east. This is particularly observable in the two western groups. The mineral is generally accompanied with zinc ores, more usually in the state of dry bone, with more or less of iron.

The series is continued north-easterly from Centerville to the Franklin diggings, one of the most extensive and important groups in the mineral district. This group is of greatest extent from north to south, and includes a number of subordinate groups, of which the most central, and also the most important, is that at the Dry Bone Hollow, north of Franklin village. These diggings are in the blue limestone, except a few of little importance in the lower part of the upper magnesian, on the higher grounds towards the south, and those in the lower magnesian in the ravines leading to Blue River, west of Franklin village. Those in the blue limestone are chiefly in the main opening in the lower part of the upper bed; the glass rock opening having been worked only in a few instances, as a lower opening, or on the outskirts of the group toward the north and east. The ground in the Dry Bone Hollow, is nearly occupied by contiguous ranges, bearing south-easterly obliquely across the hollow, and worked chiefly in the main opening in the upper bed of the blue limestone, but in a few instances the glass rock opening has been reached only two or three feet below the upper opening, and worked in connection with it. The mineral was first struck on the east part of the ridge adjoining the hollow on the north, in a thin overlying cap of the upper magnesian, where the bearing of the ranges is apparently E. S. E.—This difference in the bearing of ranges in different strata has already been noticed. South of the central group at the Dry Bone Hollow, are only a few scattered diggings; those on the west, adjoining the ravines of Blue River, in the upper bed of the blue limestone; two small groups on the divide, between Blue River and Otter Creek, in the lower part of the upper magnesian, and a range on the east of the divide (Jones'), in the glass rock opening. Copper ore has been found on a line east of Centerville, both in the blue limestone, and one of the two groups in the upper magnesian, that to the south-west. North of the group at the Dry Bone Hollow is an extensive line of diggings from west to east, forming three distinct groups—the Irish diggings on the west, West Point in the middle, and the Suddorth diggings on the east. The general bearing of the ranges is there E. S. E.—These diggings are all in the upper bed of the blue limestone, in the two western groups, in pipe clay openings, on the eastern group, chiefly in zinc openings, but in one of the ranges, in a clay opening. North of the eastern group in this line, after a considerable interval, is a detached group (the Strawberry diggings), on two parallel ridges; on the south, the mineral accompanied with zinc ore in the upper bed of the blue limestone; on the north, with clay and tiff in the glass rock opening. Still farther north, near the point of a ridge towards the Wisconsin, is a small group of diggings in the blue limestone; on the south, in the upper bed, on the north, in the glass rock. This may be regarded as the extreme northern point of the transverse series through Wingville, already noticed. The diggings in the lower magnesian, west of Franklin, are in two ravines leading to Dry Hollow, one on the west, the other on the east, where that rock underlies bluffs of the upper sandstones. Those on the west were noticed in my former report, and have been worked in the upper, softer bed of the rock, and in the thick layer of flint at the top of the middle bed; those on the east, only in the latter. These diggings have been the most productive yet worked in the lower magnesian.

The series 11 terminates E. S. E. of Franklin in the Otter Creek diggings, in a line towards the most north eastern point of the Pedlar's Creek diggings. These are situated in two ridges between ravines near the head of Otter Creek; the group on the northern ridge at (W. S. Adam's) is the most important. They are chiefly in the glass rock opening, though the upper opening is also present, but has been little productive. The mineral in the glass rock opening is generally accompained with zinc ore, but sometimes with iron or clay. The interval between the two openings is here greater than at Franklin, usually five or six feet. The bearing of the ranges is generally E. S. E., but crossings occur usually bearing south by east.

Mineral has been discovered in the lower magnesian, along the northern frontier of the mineral district, at least as far east as Franklin. At the different localities which I have visited, it has been worked to much extent only in the vicinity of Franklin. Small quantities have been found on the east side of the Mississippi, north of Ray's Landing; on Trout Run, north of Patch Grove; and on the lower part of Green river, near Anderson's saw mill. It has been found in larger quantity on the Little Kickapoo, north of the Wisconsin, in the layer of flints at the top of the middle bed, and like that at Franklin is pure and bright and usually in regular forms; shafts have been there sunk below the flint in which it is found, but it has not been traced downward.

An extensive transverse series, from the Fairplay, through the Platteville and Wingville to the Franklin diggings, has been already noticed. Similar transverse series of less moment, may be traced on the west from the Beetown to the Fenimore diggings, and from the Potosi to the Grab and Whitaker diggings, and on the east from the Wiota, through the Yellowstone, to the Blue Mound diggings, and from Skinner's to the Sugar river diggings. The general bearing of these transverse series is north by east; but the most important of such transverse series is that formed by the great body of diggings from Hazel Green to Shullsburg, on the south, the most extensive and connected in the whole mineral district, and that from the Mifflin to the Mineral Point diggings, on the north. These are in the same north by east line of bearing, and both present a number of lines of diggings in the same direction. A large vacant space around the Platte Mounds is interposed between them, and on either side of this, viz: at Meeker's Grove on the south, and at the south diggings on the north, are the most striking appearances of disturbance of the strata by faults yet observed in the mineral district. They traverse too, the middle line of the district, and are as it were, its axis. Their relation to certain appearances of the primary and metamorphic rocks to the north east will be hereafter noticed. The faults above noticed, are each in the line of a remarkable series of ravines extending for some distance from east to west, perhaps having an important relation to the east and west series.

I have already noticed the occurrence of small quantities of copper ore similar to that of Mineral Point, on the west side of Pedlar's Creek, in the upper bed of the blue limestone, and in an east and west line south of Franklin, in the same bed, as well as in the lower part of the upper magnesian. I have visited this season a group of copper diggings (McKnight's) no longer worked, on the west side of the west Pecatonica, south of Wiota.—The ore consists of the yellow and variegated sulphurets, accompanied with the blue and green carbonate and black oxyd, and is less accompanied with iron than in the more northern diggings.—It is found in vertical sheets or seams traversing the upper fine granular portion of the middle bed of the blue limestone; the sheets enlarging and contracting, sometimes it is said, two inches thick. It is accompanied with calcareous spar, partly fibrous, partly mammillary and composed of minute tables. I have also examined a new range, worked during the past year, in the copper diggings, east of Mineral Point. The ore is the vitreous sulphuret, accompanied with iron pyrites, and more or less changed to the green carbonate. It is found in a soft ochry and clay opening, with seams and pockets of black ochre, and occurs in their seams interlacing the opening ground, or in vertical and flat sheets or small bunches. The copper diggings, at Mineral Point, are not at present in a situation to judge well of their importance.

The ores of zinc in some of the northern diggings are very abundant, particularly in the two great openings in the blue limestone. The largest masses have been found in the main opening in the upper bed at Black Jack, Crow Branch and Franklin; sometimes, where interrupting the mineral, forming solid flat sheets more than a foot thick and of large extent. Very large quantities have been accumulated in the rubbish and piled away in the openings, and could be supplied at little expense of labor; probably large quantities yet remain undisturbed. Zinc works located at points, where the largest quantities of the ore might be easily procured, might well repay investment.

I noticed in my former report (p. 96) the general occurrence of iron ore in the diggings, originally in the state of iron pyrites, but more usually at present in that of ochre or hematite, from its decomposition. These are particularly abundant in the ochre openings in the lower bed of the upper magnesian, as noticed in my former report in such openings in Benton and New Diggings. They are also abundant in some such openings in the northern diggings, where the hematite is observed at times in large masses, apparently fully recomposed, particularly at Wingville. I noticed too, in my former report (p. 18) the common occurrence of seams and nodules of iron pyrites and hematite in the upper sandstone, at its junction with the blue limestone. I have this season observed a remarkable instance where the whole thickness of the upper sandstone is apparently pervaded to a large extent, and in a similar manner, by iron. It occurs on Skinner's branch, near the Pecatonica, in a line S. W. from Skinner's diggings, where a narrow ridge, on the east side of the branch, is composed of a deep red sandstone, more argillaceous than is usual, and including layers of a thin red shale, through which seams and nodules of iron pyrites or hematite, and also of brown iron-stone, are disseminated. On ascending the ridge towards the north-east, this is overlaid by a bed of light grey, indurated sandstone, equally abundant in pyrites and hematite, and underlying the blue limestone. This is the only instance of the kind I have yet observed.

Its position in the line of the transverse series from the Sugar river diggings to Skinner's diggings, is worthy of notice. It perhaps indicates that beneath the ranges in the higher limestone strata, the upper sandstone may be traversed at least by the iron ores accompanying the mineral, leading down to the other deposits of mineral in the lower magnesian.

The facts collected this season, as well as those stated in my former report, show conclusively that all the limestone in the mineral district, from the upper to the lower magnesian inclusive, are mineral bearing. The lower magnesian has been worked only on the confines of the district to the north, nor should the results there be considered as decisive of its productiveness in the central part of the district. The most productive diggings yet worked in it, are those in the vicinity of the important diggings at Franklin, in the blue limestone. The lower sandstone is found to contain extensive beds of calciferous rock, particularly in the north-western counties. f these should extend below the mineral district, and from analogy with the other limestones, prove mineral bearing, the chances of deep mining would be much increased. The opinion expressed in my former report that the mineral was derived from beneath, is strengthened not only by the general results of my observations in the diggings, but by the appearance of disturbance in the strata, particularly along the line of the great body of mineral traversing the middle of the district, and by the relation in the bearing of that body to the extensive ranges of primary and metamorphic rocks towards the north-east, indicating that the mineral may have arisen from a mass of such rocks beneath the secondary strata. This will be rendered more probable, when I describe the arrangement of these rocks in a subsequent part of this report.

But whatever may be the prospects of deep mining, a large field still remains in the strata which are known to have been productive, particularly in the more southern districts, where the series of strata is more complete. New discoveries are still made in the strata above the water level or easily accessible by draining. The large deposits discovered last winter (1854 5) in Stephen's range, (Shullsburg) and in two ranges in the south part of the Fairplay diggings, and the recent discoveries in the vicinity of Crawford's pump (Hazel Green) below the water level, may be cited as favorable instances. In any attempt at deep mining, those points where the mineral has been found most abundant in the upper openings, should be selected, and care should be taken in sinking, to follow the strongest indications. The shifting of the mineral from one line to another will cause embarrassment, but such is common in the most regular and continued veins, and the regularity and order here observed in this will render the difficulty more easy to obviate. With such evidence of large deposits in the lower strata, it would little accord with the American enterprise to be dissuaded from the search of them by failure of a few attempts, not sufficiently sustained.

GENERAL RECONNOISSANCE.

I have already stated, in the introduction to this report, that after I had completed the survey of the mineral district, I undertook a general reconnoissance, in which I aimed to traverse as much of the state as possible. In that and my other employments I have traversed more or less than thirty eight counties, all except a few of the more northern.* As I was only five months on my general reconnoissance, I could take only a hasty view of the country, and shall attempt, in this part of the report, only a general outline of the geological arrangement. If I can succeed in fixing a few land-marks, which may serve as stations in the future investigation of details, it will be all that I can expect to accomplish. I might have employed the time in a more detailed examination of a few localities of interest, but my former experience had satisfied me of the great advantage of such a previous reconnoissance in a successful pursuit of the details. I had before commencing it the benefit of a more particular examination of the formations in the mineral district, and as those include all the secondary formations in that part of the state visited, except the lower sandstone, and perhaps a few overlying strata in the west shore of Lake Michigan, I have been able to refer my observations in other parts of the state to the points which I have determined in that district. In giving the results of my reconnoissance, I shall first present a general view of the different *rock formations*, and as the secondary rocks occupy the country generally, where, not covered by the loose surface deposits, the primary rocks appearing only in a few detached points, I shall place them first in order.

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*The counties not visited are Manitowoc, Calumet, Kewaunee, Door, Oconto, Shawanaw, Waupacca, Marathon, Clark, Buffalo, La Pointe and Douglass.

SECONDARY ROCKS.

The well established secondary formations in the part of the state visited by me are the mound limestone, blue shale, upper magnesian limestone, blue limestone, upper sandstone, lower magnesian limestone and lower sandstone. These are all observed in the country south of the Wisconsin river including the mineral district, but the lower sandstone only at a low level along the valley of the Wisconsin. I have given in my former report and that part of the present relating to the mineral district the results of my observations there in relation to the formations, and shall now give such views of them as are generally applicable, and in particular the extent to which they are distributed over the surface.

THE MOUND LIMESTONE.*

This formation in the western part of the state is only found overlying a few detached mounds in the mineral district,† as well as the north point of a chain of ridges and mounds east of Galena.* On the west side of the Mississippi it occupies the highlands, an almost unbroken escarpment rising above the level of the upper magnesian, and extending at a short distance from that river, at least from Turkey river southward. It also overlies there some detached mounds, adjoining the highlands, such as Sherald's mound, and Table mound, near Dubuque. The chain east of Galena, above noticed, extends south into Illinois, where it spreads over a large surface, but is much more broken than the high lands west of the Mississippi. On the east side of the State this formation is apparently the overlying rock throughout the whole extent along the west side of Lake Michigan, including the peninsula east of Green Bay, and the islands at its entrance, and extending west to Lake Winnebago. This part of the State, particularly towards the south, is so covered with drift, that with a few exceptions it is difficult to determine there, the western limit of this formation precisely. This formation on the east side of the State is much less elevated than towards the west. On the west it dips with the other strata to the south, or rather to the west of south; but in the east, to the south east. Between the two escarpments of this formation on the west and east is a wide extent of country where it is wanting, extending south along the course of Rock river into Illinois.

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* This rock has been regarded, from its fossils, as equivalent to the *Niagara limestone.*

† The Sinsinawa mound, on the line of Hazel Green and Jamestown, (Grant county); the Platte mounds, in Belmont (La Fayette county), and the Blue mounds on the line of Dane and Iowa counties.

I have stated in my former report that in the south-western mounds in the mineral district, where the formation is more complete, three distinct beds may be distinguished an upper, abounding in fossils, particularly corals, of which the *Catenipora* may be considered as characteristic: a middle, abounding in flint, and in which too the *Pentamerus* is particularly observable; and a lower, less abundant in fossils, but which may be characterized by a peculiar coral (the *Reticulites.*) In the Patte Mounds, and western Blue Mound, the upper bed is wanting, but the middle bed is there more abundant in flint, and in the western Blue Mound, this even apparently occupies the whole bed, but the *Pentamerus* is there frequent. In the eastern Blue Mound, the lower bed is only present.

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* Terminating in the ridge at Gratiot's grove, south of Shullsburg.

On the eastern side of the State, this formation occurs generally in detached localities, presenting only a small thickness of rock, and it is there more difficult to determine the different beds, than in the south-west. The rock is most exposed in the long line of bluffs extending north from Iron Ridge, along the east side of Lake Winnebago. In that, the lower and middle bed can be distinguished; the lower usually nearly destitute of fossils, but occasionally presenting its characteristic fossil, the *Reticulites*; the middle, less abundant in flint than in the south-west, but marked as there by the *Pentamerus*. At the Bay Settlement, on the east side of Green Bay, ten or twelve miles below the town of Green Bay, the lower bed is very distinct, marked by its peculiar fossils, and underlaid by the blue shale. The latter also underlies the same bed at Iron Ridge. The *Catenipora*, characteristic of the upper bed in the mounds, is found in the quarries west of Milwaukee, at a low level, indicating a considerable dip of the strata to the east. Specimens of it were shown me at Green Bay, from the highest part of the rock at the Door, and in the adjacent islands. It is found in blocks on the surface in the middle and eastern parts of the district occupied by this formation. Such blocks are frequent on each side of the range of drift hills called the Pots and Kettles, in the western part of Sheboygan county.

The rock of this formation presents a peculiar lithological character by which it may be distinguished from the other limestones. It is usually of a nearly compact grain of a light grey or light cream color, approaching white, is easily dressed, forming, when sufficiently thick, a good material for building, and at times admits of a sufficient polish to be called a marble. This is particularly true of the lower bed. These characters are so very similar in the south-western and eastern parts of the state that the rock can be easily identified. Layers of a thinner compact subargillaceous rock of a very even grain, occasionally occur, particularly in the lower part of the lower bed as it approaches the blue shale. Specimens of this from the Door, at the entrance of Green Bay, have been tried and approved for lithographic purposes. An appearance has very generally presented itself in this rock, particularly in the lower beds which I have never observed in any other limestone, and by which it may be distinguished. This is the occurrence of numerous finely grooved seams, which in one instance (on the south fork of Pine Creek, in Kenosha county) were occupied by thin layers of bitumen, but in most instances this is evidently wanting.

In traversing the eastern part of the state I have had but few opportunities of seeing the rock of this formation in place. It is exposed most continuously on its western border towards the north at least as far south as Iron Ridge. South of that point the county is so covered with drift, particularly along the range known as the Pot's and Kettles, which may be considered near the western line of this formation, that the rock is exposed only at a few points and those generally at low levels. In its eastern part, through the whole extent traversed, only a few points of rock are exposed, generally in the bluffs and beds of rivers or near the water level on the shore of Lake Michigan. At the entrance of Green Bay, the rock is more elevated, forming high and abrupt bluffs, but that point I have not yet visited. Specimens shown me at the town of Green Bay, prove sufficiently that the rocks there are of the present formation. Immense accumulations of limestone drift (boulders and cobblestone), are found on the surface of this formation, particularly along the line of the Pots and Kettles, generally having the character of its rock, and sometimes distinguished by its peculiar fossils.

The most northern point visited by me is at the Bay settlement on the east side of Green Bay already noticed. Here the rock of this formation forms a low bluff about a mile back from the shore and is evidently the lower bed, marked by the *Reticulites*. It is crossed by a small stream forming a cascade, by which the rock is excavated so as to expose the underlying blue shale. From this the western line of the formation extends S. S. W., east of Depere to Clifton at the north-east corner of Lake Winnebago, and thence south in the ridge east of that lake by Taycheedah towards Iron Ridge. At Taycheedah, where I crossed it, the middle and lower beds may be distinguished, but I did not observe there any fossils. In the long line of bluffs extending from near Mayville to Iron Ridge there is the same deficiency of fossils in the lower bed, but in the middle bed which is seen only in the higher part of the bluffs towards the north, the *Pentamerus* may be distinguished. West of this line of bluffs, blocks of mound rock are found scattered over the surface as far as the east side of Lake Horricon. The lower bed at Iron Ridge, is immediately underlaid by the bed of iron ore which itself is underlaid by the blue shale. At Hartford, though in a line farther east, the lower bed is observed near the rublicon overlying the same bed of iron ore, on the south side of that stream, but on the north side sunk apparently by a fault below its level. The rock is here deficient in fossils as at Iron Ridge, but a pocket of red and white clay was exposed in it, in a cut of the railroad, adjoining which fossils were more abundant. Proceeding south from this I have observed the rock of the present formation in place only at Waukesha, Casselman's quarry in East Troy and Voree near Burlington. In all these localities the rock has the characters of the lower bed, as it is seen in the mounds and ridges towards the Mississippi. It is the same light colored nearly compact rock, easily dressed, and often admitting a good polish, and when sufficiently thick, is a valuable material for building. This is particularly the case at Waukesha and Casselman's quarry where the rock is thicker and firmer. At Voree it is thinner and softer and alternates with layers of shale, and apparently lies near the base of the formation. In all these localities fossils are unfrequent, but occasional layers occur in which they are more abundant. The rock in all these localities is at a low level, raised but a few feet above Fox river, or its branches, to which they are contiguous. Farther south in Wheatland, a large accumulation of blocks was found, on the east side of Lake Nipirring apparently from the breaking up of an underlying ledge, and similar in character to the thicker bedded rock in the preceding localities.

East of the localities above noticed along the apparent line of the lower bed the rock is very rarely exposed until we reach another parallel line near to Lake Michigan. A limestone nearly or quite destitute of fossils is exposed at Sheboygan Falls, at Pigeon river north of Sheboygan, and at the light house near the latter place; in the two former instances little elevated, and in the latter at the bed of the lake. It is in alternate layers, light grey, or nearly white and sub crystalline, and blue, and more compact, and is apparently unlike the rock of the lower bed, and from its want of fossils cannot be readily identified. At Grafton (Ozaukee county) an extensive range of limestone rock is exposed along the Milwaukee river, having the general character of the present formation, the greater part containing very few fossils, but a few layers abounding in them. About three miles north of Racine, at Cooley's and Toes' quarries, beds of limestone rock have been excavated but a few feet, some of the layers of which abound in fossils similar to those at Grafton, and at the rapids of Root river nearly west of these, a similar fossiliferous rock is exposed. In a line between Grafton and Racine, along the Menominee river, west of Milwaukee, a limestone is exposed abounding in fossils, and in which the *Catenipora* is observed. This fossil I have not noticed at Grafton or Racine. This range of fossiliferous limestone, extending north and south from Grafton to Racine, is apparently the upper bed of the present formation clearly identified in the rock west of Milwaukee. The rocks in the vicinity of Sheboygan are in a line farther east and perhaps may form an overlying bed.

THE BLUE SHALE.

This has already been noticed in my former report, as underlying the mounds, at all of which it has been exposed by excavation. As it is composed of a thin argillaceous slate, readily decomposing into a soft clay, it is always concealed unless thus exposed. The slate itself is apparently without fossils, but at and near its base at the mounds are a few thin fossiliferous and concretionary layers, which are also found in a bed of pipe clay overlying the upper magnesian in different places remote from the mounds. This circumstance was noticed in my former report as indicating an apparent extension of the blue shale over the upper magnesian. This same bed of blue shale may be observed in the eastern part of the state, underlying the mound limestone, where that rock is sufficiently elevated to expose it. Thus it is exposed at the foot of the cascade at the Bay Settlement, and has been found by excavation to underlie the bed of iron ore at Iron Ridge. The resemblance of the rock at these localities to that underlying the mounds is obvious. The position of the bed of iron ore at Iron Ridge is apparently in the upper part of this formation, and in the same position at the Bay Settlement, traces of a similar iron ore may be distinguished. But at the base of the blue shale in the eastern part of the state instead of the few thin fossiliferous layers at the mounds, there is a third bed of fessiliferous limestone very similar to the shell beds in the upper part of the blue limestone, and which might at first be mistaken for it. It abounds like that in shells of the genus *Leptæna*, and in some of its layers is round and flattened branched corals, which are also observed in the shell beds of the blue limestone, but are there much less abundant. The fossiliferous layers in the shale of the mounds differ entirely in their shells from this shell bed, in the eastern shale, but similar branched corals are observed in them, forming as it were a connecting link with the latter. This shell bed extends along the shore of Green Bay at the Bay Settlement, and is found in some of the small streams in that vicinity, evidently at a small depth below the mound limestone. At Iron Ridge it has been found in sinking below the bed of iron ore at the depth of from ten to twenty feet below the latter. It exhibits there the same shells and corals as at the shore of Green Bay.

THE UPPER MAGNESIAN LIMESTONE.

The character of the rock of this formation in the mineral district has been described in my former report. I have stated there that it most usually occurs partly fine grained and compact, and partly coarse grained and more crystaline, or even with small geodic cavities. These dictinct parts are arranged in a concretionary manner, and as the coarser grained is more decomposible the rock has often a peculiar cavernous appearance.— This character of the rock prevails more or less in other parts of the state where it is distributed. But even the more compact parts of the rock, unless when in very thin layers, exhibit a peculiar subcrystaline grain, by which it may be distinguished from the other limestones. In the mineral district, three distinct beds in this rock may be distinguished, the middle of which is characterized by an abundance of flints, usually arranged in regular layers. The flints in this rock are always in nodules, and compact; crystalized quartz is very rarely observed. Flints, too, are found more or less in the upper and lower beds of this rock, particularly the latter, and in this it contrasts strongly with the underlying blue limestone. In the lower bed in the mineral district, the rock is sometimes observed of a dark brown color (the brown rock), and at other times marked with green seams (the green rock), but is then only stained with iron, usually in connection with mineral openings. This rock is not abundant in fossils, although in some of the thinner layers, particularly at the junction of different beds, they are more frequent. The honey comb coral (*Coscinopora*) is the most distinctive fossil of this formation, and so far as I have observed, is confined to it. It was in this rock that mineral (lead ore) was first found, and in the more southern diggings, it has been worked almost entirely in it; but in the more northern districts, the blue limestone is equally productive.

The upper magnesian is the overlying rock throughout the greater part of the country in the south western part of the state south of the Wisconsin, and west of Sugar river, forming the mineral district. It is there little interrupted towards the south and west, but towards the north and east is more broken and denuded. The subjacent strata are observed towards the south and west only in the valleys of the rivers, but towards the north and east they occupy a greater extent of the surface, the upper magnesian there appearing only on the higher ridges. It is from the valleys of the rivers that the denudation of the upper strata has proceeded, and while these have only been broken through towards the south and west, exposing the lower strata in the bluffs, they have been removed to a greater or less extent towards the north and east, the strata receding from the valleys in successive terraces from the lowest to the highest. Some exceptions to this general statement occur in the interior of this district, caused apparently by elevations of the strata at different centres noticed in my former report. Such centres of elevation were there pointed out on Fever river, at Meeker's Grove, on the West Pecatonica, at Mineral Point, on the East Pecatonica, at Argyle, on the Big Platte, at Ellenborough, and on Grant river. At these centres of elevation the lower strata are more exposed, and occupy successively receding terraces in the manner above indicated, but to a much less extent than on the north and east of the district. In addition to the above, I have noticed this season a remarkable line of elevation along the north of the Platte Mounds, from the west fork of the West Pecatonica, at the South Diggings, along the Little Platte, apparently leading from the centre, at Mineral Point, towards that at Ellenborough, and corresponding to that towards the south, on Fever river, at Meeker's Grove; also a centre of elevation on the West Pecatonica, south of Wiota, where the lower magnesian is exposed, and another on Skinner's branch, near its junction with the Pecatonica, including the remarkable locality of ferruginous sandstone noticed in a former part of this report. The upper magnesian has been broken through on the Mississippi, from Dunleith northward; on the Big and Little Platte and Grant river, from their mouths nearly to their sources; on Fever river from near Meeker's Grove, on the north, to near Galena on the south; on the different branches of the Pecatonica, from near their sources south into Illinois. It will thus be perceived that the greater extent of surface where it is unbroken, is in the tract extending north between the Mississippi and Fever rivers, then east between the centre of elevation on the latter river and the Little Platte, then south between Fever river and the West Pecatonica. Another extensive tract where it is unbroken, extends between the Mississippi and Grant rivers, including Blake's Prairie, and a third along the divide south of the Wisconsin, from the valley of Sugar river by the Blue Mounds, to the head of Pine Fork, a branch of Grant river. These two latter tracts are there separated by a narrow break through the lower sandstone connecting the valley of Pine Fork with that of Green river, a branch of the Wisconsin.

The remarks which have been made above on the successive denudation of the strata, will apply to the different beds of the upper magnesian; the upper being most denuded towards the north and east, and around the different centres of elevation. This circumstance is of importance in mining, as showing the extent of mineral rock, and the probable number of openings which may be expected in any locality. It is known that as we approach the north, or the centres of elevation, the diggings are found successively in the lower beds of the upper magnesian, and finally of the blue limestone. The details of this have been given already in connection with the mineral district.

Beyond the district, south of the Wisconsin and west of Sugar rivers, the upper magnesian occupies a less extent of surface.

On the north of the Wisconsin, it overlies the summit of the ridge between the Mississippi and the Kickapoo, for a few miles towards the south. Between Sugar river and Rock river it may overlie some of the higher ridges and prairies towards the south line of the State, such as the high ridge between Sugar river and the valley at Footsville, and the high prairies west of Janesville. I have only observed these on the road from Monroe to Janesville, and on the west side of the former found the upper sandstone so elevated as to leave little room for the upper magnesian, while the summit was so covered as to conceal the rock. On the west side of the latter are several quarries of blue limestone, the highest apparently near the junction of the upper magnesian, leaving room on the higher summits for that rock, but these were so covered with drift, that it was not observed. East of Rock river, the upper magnesian occurs in the sides of a higher prairie south of Rock Prairie, where it is quarried at different points near Emerald Grove, east of Janesville. This prairie extends from this point south-west towards Beloit, of the same elevation, and is partially occupied by this rock. North from this, I have next observed it in a number of quarries on a group of low ridges south of Bark river near Fort Atkinson. Near the tops of the ridges it contains frequent layers of flints, but near the base these were not observed, and the thicker bedded rock is there accompanied with thin marly seamed layers, closely resembling a rock frequently occurring at the rapids of the lower Fox river. The rock in all of these localities east of Rock riuer, has distinctly the characters of the upper magnesian, its sub-crystaline grains and its flints, and also its peculiar fossil, the *Coscinopora*. It is quarried there for building, and in its upper flint beds near Fort Atkinson, for lime. The next point towards the north, where I observed the upper magnesian, was at two quarries north of Watertown, on the road to Oak Grove. It there contains flints, and like the corresponding rock near Fort Atkinson, is burnt for lime. The upper magnesian then extends by Hustisford and Oak

Grove, and the west side of Rolling Prairie, east ot Fox Lake to Waupun. It lies throughout this extent at a low level, generally concealed by drift, and has been exposed only to a slight depth by quarries. At Waupun it terminates in a low bluff towards the west fork of Rock river, but underlies a large extent at a few feet from the surface. The rock in this part of its course is harder and firmer than further south, and is well adapted for building. The State Prison at Waupun is built of this material. The surface of the rock, wherever its covering of drift has been removed, has been found smoothly polished and marked with scratches bearing north east. This rock, though deviating somewhat in its character, is still clearly identified with the upper magnesian by its peculiar fossil, the *Coscinopora*, which is here of general occurrence. A range of drift hillocks, chiefly composed of fragments of limestone, apparently the upper magnesian, as it here occurs, extends in a north easterly course across Rolling Prairie. These fragments, as well as the rock in the quarries, are burnt for lime.

The extent of the upper magnesian as far as Waupun along the line above indicated may be considered as clearly determined.—Its precise extent from east to west, I have not been able to determine, but it may be considered as occupying the space between the western line of the mound limestone on the east and the range of the blue limestone on the west, which will be afterwards pointed out. It appears to extend from west to east at least from the vicinity of Fox Lake to the east of Lake Horicon. Farther to the north east its course is less clearly identified. The rock in the line of its direction, at and near Oshkosh, and along the Lower Fox river, to Duck Creek, north of the town of Green Bay, although differing considerably from that farther south, and although I have nowhere observed in it the *Corcinopora*, has yet presented throughout rather the character of the upper magnesian than of the other limestones. Two varieties are observed here more particularly; one a very hard, nearly compact thicker rock, with blue marly seams, covered more or less with figures which have been considered fucoidal, but which appear to me obviously concretionary, there being a want of regular recurring forms and of internal organic structure; the other marked by a peculiar parallel structure as if composed of very thin marly seamed layers, firmly cemented, but without the peculiar concretions of the other.—These varieties although more strongly marked here have yet been observed farther south in the upper magnesian. Very few fossils have been found in the rock on the Lower Fox river, and these so far as I have noticed are common to the upper magnesian. The upper magnesian if thus continued will extend in a regular course very nearly north to Lake Butte des Morts and Oshkosh, and then more north-easterly along the lower part of Fox river parallel to the western line of the mound limestone in that part of its course. The shell bed along the east side of Green Bay, which I have identified with that at Iron Ridge, underlying the mound limestone, will thus be found in its true position above the upper magnesian. The shell bed in the blue limestone will be traced along a line west of Fox river.

THE BLUE LIMESTONE.

The character of this formation, and of the different beds into which it may be distinguished, has been given in detail in my former report, and that part of this report relating to the mineral district. It has not the same uniformity of character throughou as the upper magnesian, the different beds being easily distinguished. I have described three different beds of which the two upper may be divided into distinct portions. The upper bed consists of an upper and a lower portion, the latter highly fossiliferous and forming the upper shell bed of this formation. This shell bed, like that underlying the blue shale is peculiarly marked by shells of the genus *Leptæna*, but contains few of the corals so abundant in the latter. It is in connection with this shell bed that the main upper opening in the blue limestone is situated. The middle bed may be divided into three portions, but of variable thickness, one sometimes to a certain extent replacing another.—The upper fine-granular portion forms the cap rock of the glass rock opening. The middle compact thick bedded portion forms the glass rock of most miners. The lower, compact, thinner and more marly seamed portion is the most fossiliferous part of the formation next to the shell bed above noticed, but is rarely marked by *Leptænæ*. It sometimes replaces to a large extent the middle portion. The lower bed or buff limestone is more uniform in its character, except near its junction with the upper sandstone, where marly and sandy, and sometimes oolitic layers occur.—Throughout the whole extent to which I have traced this formation, these distinctions may be observed more or less obviously, as far as the rock is present, for in some instances the upper part of the rock has been removed. This rock in the mineral district has been mineral bearing as well as the upper magnesian, and in the northern diggings, as productive, particularly in its two main openings.

The blue limestone nowhere occupies such an extent of surface as the upper magnesian. In the country south of the Wisconsin, and west of Sugar river, it forms only narrow terraces on the north and east towards those rivers, and in some instances around the centres of elevation already noticed, or occurs underlying the upper magnesian in the bluffs of rivers and ravines. On the Mississippi it appears underlying the upper magnesian, from Dunleith northward, but nowhere extends back from that river, except on its branches and in ravines, till we approach the Wisconsin. On the lower part of the Big and Little Platte, and Grant rivers, it is generally confined in the same manner; but on the upper part of those streams, around the centres of elevation above noticed, it extends farther back, occupying a portion of surface adjoining the main valleys. This is particularly observable around the head of Pine fork (Grant river), south of the break through to the Wisconsin, already noticed, on the Big Platte, Near the New California and Crow Branch diggings, and on the Little Platte, south-east of the latter, north of the highest point of elevation on those rivers. On Fever river, the blue limestone is exposed throughout the whole extent that the upper magnesian is there broken through- but is confined to the immediate vicinity of the river and its branches. It extends in that manner along the Shullsburgh branch nearly to Shullsburgh. It entends in the same manner along the Pecatonica and its branches, but recedes farther around the centres of elevation noticed at Mineral Point, south of Wiota, and at Argyle and Skinner's branch. The lower strata have indeed been so elevated in the country drained by the Pecatonica, that the blue limestone may be traced along its numerous branches nearly to their sources, and at some points besides those above enumerated, is exposed to a larger extent than usual. This may be observed on the lower part of Pedlar's Creek, and on the west fork at the south diggings, along the supposed line of elevation, north of the Platte Mounds, and also on the Dodgeville branch, east of Dodgeville, at the numerous diggings in the glass rock opening.

North of the Wisconsin the blue limestone overlies the sides of the ridges between the Mississippi and the Kickapoo towards the south where the summit is occupied by the upper magnesian, and extends to the top of the bluffs east of Prairie du Chien, where the middle and lower beds may be distinguished. North of the upper magnesian it overlies the summit, at least to the iron mountain, north of which it only forms caps of more or less detached ridges or mounds of the upper sandstone, extending chiefly along the divide, but in a few instances on the sides of the main ridge. It caps those ridges or mounds nearly as far north as Viroqua, beyond which they are composed only of the upper sandstone.—The arrangement of these ridges will be explained in connection with the upper sandstone. Only the lower bed of the blue limestone is usually present in the caps of these ridges.

In the wide valley of Sugar river the blue limestone only forms caps of mineral detached ridges, usually rising in bluffs in the middle of the valley, and in these caps also, only the lower bed is usually present. Sometimes the summits of these ridges from a considerable plateau covered with a fertile soil. A group of such ridges occurs north east of Dayton, and another adjoining the village of Decatur on the north-west. A range of country traversed by the blue limestone passes around the head of Sugar river on the north and extends across the south part of Dane county, and the north part of Rock county to Rock river, or rather to the western line of the upper magnesian east of that river. The blue limestone does not here overlie the entire surface, but forms caps of the higher ridges, while the lower swells are composed of the upper sandstone. In some of the higher capped ridges all the beds of the blue limestone may be distinguished, and in other lower ridges only the lower bed. The rock, particularly in the middle and lower beds, is often quarried for lime and building. South from this tract the blue limestone is exposed along the sides of the high prairie ridges west of Rock river, particularly on the west side; namely, the ridge between the valley of Sugar river and that at Footville, and the ridge between the latter valley and Janesville. On the west side of the former ridge it overlies the upper sandstone at a high level, but on the west side of the latter it lies lower, and all its beds may be distinguished. In the vicinity of Janesville it appears in low bluffs along Rock river, particularly at the Monterey quarries on the south, and in the west bank of the river about two miles north. In both these it overlies the upper sandstone, but at a higher level in the bluff towards the north. At Monterey the three different beds may be distinguished. The lower bed, although chiefly stained buff, is in some layers marked by its natural blue color, and as in other localities is well adapted to building, and even admits of a polish like marble. Turning north, the blue limestone is apparently the overlying rock, through a wide tract extending from Rock river at Lake Koshkonong to the vicinity of the Third Lake at Madison. At Lake Koshkonong it sinks to the water level, but on Koshko.

nong Creek and other streams farther west the upper sandstone is largely exposed. This part of the country is extensively covered with drift, but the blue limestone is found at many points, near the surface, particularly on the prairies where the drift is usually less accumulated. Farther north, this tract extends to the east side of Sun Prairie, where the blue limestone may be observed overlying the upper sandstone. As we proceed north in the direction of this tract, the country is so covered with drift that few opportunities occur for observing the blue limestone. It occurs, however, north-west of Portland where the lower bed is found overlying the upper sandstone, and south west of Columbus where it appears along an extensive range, the upper sandstone exposed only by excavation, and in some points, as at Allen's quarry, the two lower beds well marked. In that quarry small quantities of lead have been found particularly in the middle bed. The line of direction of the blue limestone continued north would pass by the west side of Fox Lake, but I did not there observe it. It appears, however, in the escarpment along the east end of Green Lake, overlying the upper sandstone at a high level, and bearing around to the east, occurs in a similar position above the sandstone at the quarries at Ripon and Ceresco, on the east and west sides of the deep valley passing through the latter. At these quarries the middle and lower beds can be distinguished. North of this its course has already been indicated to me, by a thin layer overlying a low detached ridge west of Waukau composed of the upper sandstone resting on the lower magnesian, which there underlies the surface generally. A well marked specimen of the shell-bed of the blue limestone was shown me at Appleton from the town of Freedom, north of Kaukauna, indicating the course of that rock near the divide between Fox and Wolf rivers.

THE UPPER SANDSTONE.

This rock has been described in my former report, as it occurs in the mineral district. It has exhibited nearly the same characters wherever I have observed it, and my observations this season have presented but few peculiarities worthy of notice. The most remarkable is that occurring on Skinner's branch, noticed in the former part of my report, where nearly the whole thickness of the rock is colored deep ore by oxyde of iron, and nodules of iron pyrites and hematite are disseminated throughout. This dissemination of iron is common in this rock, at its junction with the blue limestone, but in no other instance have I observed it in this manner pervading the whole. This rock is generally composed of uniform fine grains of quartzose sand, usually very little coherent in the interior, but hardening on the surface so as to resist decomposition more than the adjacent limestones, consequently the bluffs of sandstone remain abrupt and prominent, whilst the limestones are concealed. I have in no instance observed this sandstone indurated, as if by metamorphic action, so as to resemble a quartz rock. This is said, however, to occur at the knob north of Ridgeway, already noticed, but I have not had an opportunity of verifying it. Such induration I have repeatedly observed in the lower sandstone. This rock is usually thick bedded, but sometimes in thinner layers, and even schistose, particularly along the branches of the Pecatonica and Sugar river. It never presents calciferous beds like those so common in the lower sandstone. This is probably owing to its occurrence as a comparatively thin bed, between very thick masses of limestone, while the lower sandstone is a formation of very great thickness, in which calciferous beds, sometimes forming well marked limestones, are deposited, as the upper sandstone is deposited among the limestones.

The upper sandstone follows closely in its distribution the overlying blue limestone. In the mineral district it forms lines of bluffs along the outskirts of the terraces of blue limestone, or appears merely as a bed in the abrupt sides of valleys and ravines. Bluffs of this sandstone extend all along the northern frontier of the mineral district, towards the Wisconsin, extending far into the valleys and ravines, and to a considerable extent, though less uniformly, along its eastern frontier towards Sugar river. In the interior of the district, this sandstone is exposed along the valleys of streams in the same manner as the blue limestone, but to a less extent, and in some instances at the centres of elevation, presents low detached ridges quite isolated. On the Mississippi it rises above the water level south of Platte river, but apparently sinks again below it above Potosi, not being exposed at Cassville, nor on Grant river at Waterloo. It again rises north of Cassville, but along that part of the Mississippi is apparently of little thickness. It appears on Grant river south of Beetown, and extends to the upper part of that river and its branches, and in particular is largely exposed near the break at the head of Pine Fork already noticed. I extends along the Big Platte, far towards its source, and from the extraordinary elevation on that stream at Ellenborough is sometimes largely exposed. This is observed at the ferry east of Potosi where it forms by itself a low ridge in the valley, underlaid by the lower magnesian, and also north of Whittaker's diggings, where it presents bluffs, one of them abrupt and isolated. On the Little Platte, in the middle part of its course, it is not exposed, but it again appears, in the upper part of its course, at the apparent centre of elevation north-west of the Platte Mounds. On Fever river it occurs only for a short distance, at the point of elevation, at Meeker's Grove, and on the east side forms there a low terrace of some extent uncovered by the blue limestone. On the West Pecatonica it is largely exposed at the centre of elevation, near Mineral Point, particularly on the east fork west of that village. It extends from that centre towards the sources of the different branches of that river, but less far than the blue limestone, and towards the south only in the vicinity of Bonner's branch, while the blue limestone is apparently exposed along the whole course of the river to the centre of elevation south of Wiota. The upper sandstone is there again exposed, forming low detached swells in the valley. On the East Pecatonica it is exposed in a similar manner at Argyle, and from this centre, bluffs of this rock may be traced along the main stream and its branches far towards their sources, in some places apparently higher and more detached than others, marking points of greater elevation. This occurs on the Dodgeville branch, south-east of Dodgeville, where the rock makes a large dip to the south. At the centre of elevation, on Skinner's branch, this rock forms several detached ridges and bluffs, and is to a large extent uncovered.

North of the Wisconsin, between the Mississippi and the Kickapoo, the upper sandstone extends along the sides of the ridge towards the south, and overlies its summit for a short distance north of the iron mountain. Farther north, it appears only in more or less detached ridges or mounds, along the summit of the main ridge, but in a few instances along its sides, generally overlaid by the blue limestone, nearly as far north as Viroqua, but farther north uncovered. These ridges have generally an east and west direction across the divide, but in some instances these east and west ridges are connected by north and south ridges extending along the divide, so as to form a continuous series. The most southern of these ridges is Mount Sterling, entirely detached and covered with blue limestone. Towards the north the sandstone becomes more detached, and presents only small mounds and points of rock on the higher parts of the surface. The farthest north to which this rock extends, is along the north of Coon Prairie, in the north part of Bad Ax county. In two remarkable instances, the sandstone forms high detached pillars of small diameter, the remains of more extended masses. One of these, called the monument, is on the ridge road south of Bad Ax village, at the east point of a ridge of sandstone. Its diameter is least towards its base, and it appears near its fall. The other is north-west of Viroqua, near the road from Springville to Coon Prairie. These high and slender pillars here stand on a common platform, and are known as the three chimnies. They are part of a line of detached sandstone rock extending north from an east and west ridge of the sandstone. On the east side of the Kickapoo, on the road from Viroqua, by Reed's Mills, to Port Andrew, on the Wisconsin, the upper sandstone appears only as detached outliers on the tops of ridges of the lower magnesian, and that only on the south towards the latter river.

In the valley of Sugar river, beside the high detached ridges capped by the blue limestone already noticed, the upper sandstone forms by itself lower ridges and swells, and probably underlies many such where it is concealed by drift. Near the head of the valley, at Cross Plains, a remarkable detached ridge of this rock occurs in the middle of a large basin between swells occupied by the lower magnesian, in which the latter rock is higher than the base of the sandstone, offering a satisfactory instance of the undulation in the strata. East of Sugar river the upper sandstone appears an attendant of the blue limestone, either underlying that rock in bluffs, or on the sides of ridges, or forming low swells where the higher ridges are over laid by the latter. It may be traced here and there throughout the tract occupied by the blue limestone, east to Rock river, and then north to the detached ridge west of Waukau, already noticed. Along the west border of this tract, where it extends towards the north, I have observed no outliers beyond the limits of the blue limestone, except along the east side of Sun Prairie, north of Madison, where it caps low ridges occupied by the lower magnesian. In general, throughout this whole extent, from Sugar river, the sandstone presents its usual character even to the most northerly locality near Waukau. It is everywhere the same white, fine grained, friable quartzose sandstone, more or less liable to stain red or yellow, and the peculiar characters noticed near its junction with the blue limestone, are often observed. In once instance, in the west bank of Koshkonong creek, at the village of Clinton, I observed a peculiarity in this rock which I have no where else noticed. A bed of thicker, hard, grey jointed sandstone was there traversed in its middle by a band of thin, white, marly sandstone, itself traversed in the same manner by nodules and layers of white flint. The sandstone here rises high on the side of the ridge east of the creek, and this peculiar bed must be towards the lower part of the rock. The occurrence of flint in a calcareous bed in the sandstone, illustrates the segregation process by which flints were formed in the limestone.

THE LOWER MAGNESIAN LIMESTONE.

This formation I had not examined through its entire depth previous to my former report, but had then observed in it two distinct beds analogous to the upper and middle beds of the higher limestones, and suggested a third l wer bed, which my observations this season have verified. I noticed as distinctive characters of this formation a peculiar concretionary nodular structure, and the occurrence of geodes lined with minute crystals of quartz, and of layers of flint less interrupted and nodular than in the preceding limestones, either abounding in geodes of quartz or resembling a striped jasper and then rarely geodic. The nodular structure is exhibited particularly in the weathered surface, and most in the middle bed. The layers of flint are chiefly observed in the middle bed, where they sometimes occur nearly massive, forming small subordinate beds. A thick bed of this kind occurs near the upper surface of the middle bed accompanied with thin layers and seams of green marl, and the position in which most of the mineral found in the lower magnesian, has been discovered. Layers of a thin laminated flinty quartz are found in this subordinate bed along with the varieties of flint above noticed. The flint where the mineral is found is much stained with iron or accompanied with iron pyrites, thus presenting the characters of an opening. Besides the geodes lined with minute crystals of quartz, which are found chiefly in the flint, and when in the limestone are inclosed in a very thin coat of flint, other small geodes are observed in the limestone, particularly in the lower bed lined with small but less minute crystals of white quartz. These last I have observed in the beds of limestone occurring in the lower sandstone, but the flint of the lower magnesian appears to be peculiar to that rock. The upper and lower beds much resemble each other, and are composed of a more even compact limestone than the middle bed, but in which the nodular structure above noticed may be observed. Alternations of marly and subsilicious layers occur in these beds but chiefly near their junction with the adjacent sandstones. In that position too, politic layers are generally observed. The middle bed is composed of a harder and purer limestone, of a more distinctly nodular structure, and abounds in flints like the middie bed of the upper magnesian. The lower magnesian is nearly or quite destitute of fossils, nor have I yet observed any wherever I have examined it. Caves are found in it apparently more frequently than in the other limestones, and there generally abound in stalactites, the whole cavity being often lined with them. A remarkable cave of this kind occurs on the Little Kickapoo near the discoveries of mineral noticed in the former part of this report. Sink holes are very common on the surface of this rock, caused apparently by subjacent caves. They are found too on the surface of the upper magnesian, and even of the blue limestone in the mineral district, sometimes equally remarkable, but are there less frequent. In one instance near Lodi, (Columbia county) on the south-west, I observed a vertical crevice in the lower magnesi n chiefly occupied by a massive fibrous carbonate of lime accompanied with ochre resembling a mineral vein, but no ore was apparent. This substance might be used for ornamental purposes, but is in too small quantities for other use. The Richland marble is apparently situated in the present formation, but I have not yet been able to visit it. The lower magnesian is quarried for building, particularly in its lower bed, and in some instances is burnt for lime, and although this is inferior in whiteness and slow in slacking, yet it forms a strong mortar.

South of the Wisconsin, the lower magnesian is little exposed, except in the vicinity of that river. It first appears on the Mississippi, at Ray's Landing, and rises as it proceeds northward, forming a lower terrace of bluffs to the Wisconsin, where the greater part of its thickness is exposed. Along the south side of the latter river, it forms a line of bluffs along the main valley, and extends in the same manner into the valleys of the different branches, and even into the ravines nearly to the divide at the military road forming narrow terraces or slopes, where the upper part of the rock is concealed. In ascending the Wisconsin, the lower sandstone emerges, and the lower magnesian rises gradually higher in the bluffs. In the interior of the mineral district, this rock is exposed more or less at the centres of elevation already noticed. On Grant river it appears east of Beetown, and rises in low bluffs at Barber's Mills, above the junction of Pine Fork. On the Platte, it emerges near the ferry east of Potosi, and at Ellenborough, rises on the west side of the Big Platte, to at least a hundred feet, occupying a point in a bend of the river. Near Mineral Point, it appears in a low bluff along the east fork of the west Pecatonica, above the junction of Pedlar's Creek, and may be seen just emerging at other points in that vicinity. South of Wiota, it rises a few feet in the east bank of the west Pecatonica, at J. McKnight's, on the road to Winslow. At the other centres of elevation, I have not observed it. It appears at a few detached points in the valley of Sugar river, and would probably be there largely exposed if it were not concealed by drift. In my former report I have noticed its occurrence at a few feet beneath the surface in the plain east of that river, and at a small elevation on its west fork at Primrose. It occupies several low swells in a basin at Cross Plains, near the head of that river, already noticed, and has lately been exposed by excavation in a similar swell on the south of Dayton village. The valley of Sugar river offers an extensive denudation of the upper strata, through a large part of its extent, probably to the lower magnesian.

North of the Wisconsin, it forms a low terrace, in the valley of that river, near its junction with the Mississippi. It extends along the sides of the main ridge between the Mississippi and the Kickapoo, forming a line of high bluffs, east of Prairie du Chien, where it reaches to the level of the plain, and is overlaid by the upper sandstone and blue limestone. Farther north the lower sandstone emerges, and the lower magnesian rises higher in the bluffs, while the overlying formations recede more and more towards the summit of the main ridge. South of Mount Sterling the lower magnesian extends across that ridge, and farther north occupies the surface except at the detached ridges and mounds of sandstone, already noticed, as far as the south side of the valley of the La Crosse river. Towards the north, as we approach the Mississippi, and the Kickapoo, it is more and more invaded by the lower sandstone, which gradually rises to the tops of the bluffs, leaving only a thin cap of the lower magnesian at the summit. On the south of the La Crosse it apparently terminates at some distance from the main valley. In descending the Little La Crosse it appeared to run out on the tops of the bluffs, at least five or six miles south of the Leon, near the south side of that valley. In ascending from the town of La Crosse by the State Cooley, the bluff at the head of the latter, at least three miles from the Mississippi, were composed entirely of lower sandstone. The northern frontier of the lower magnesian then apparently extends along the south side of the La Crosse valley, and may be continued west along the south side of the valley of Root river (Minnesota). These two valleys lie in nearly the same east and west line, and form a remarkable break across the country in that direction. Outliers of the lower magnesian may be found beyond that line, but the beds of limestone which I have observed farther north has appeared to me subordinate to the lower sandstone. I have not yet had an opportunity of tracing the frontier of the lower magnesian from the Little La Crosse to the east side of the Wisconsin, opposite Sauk City, but it must pass west of the Little Baraboo and south of Sauk Prairie, where the lower sandstone occupies the surface, only a few outliers of the lower magnesian being found near the former. This latter rock at least occupies the surface in the south western part of Richland county on the road from Reed's Mills to Port Andrew, overlaid only by a few outliers of the upper sandstone.

I have already stated the manner in which the lower magnesian extends along the south side of the Wisconsin. Its southern border there apparently extends east south-easterly from some point north of the head of Sugar river, by the south side of the prairie at Middleton, to the east point of a ridge south of Dead Lake, near Madison. It appears again north of Madison, near the east side of Sun Prairie, where it is overlaid by the upper sandstone. Between these two points the lower sandstone is exposed adjoining the Fourth Lake, particularly on the south, at the quarries west of Madison, in one of which at least it is distinctly overlaid by the lower magnesian. From this exposure of the lower sandstone and on the east side of Sun Prairie, north of it, the lower magnesian apparently extends across the country to the east side of the Wisconsin, opposite Sauk City, above noticed; and may be traced thence north north easterly, within corresponding limits, at least to the east side of Wolf river, at Hortona. Its western frontier or outcrop, may be most easily traced, as it generally presents an escarpment in that direction, towards a lower surface, occupied by the lower sandstone. I have crossed this frontier on the east of Lodi village, about half way between Otsego and Wyocena, two or three miles east of Marcellon, and about the same distance north-west of Kingston. It then passes by Princeton, on Fox river, north of which I have observed it between Berlin and Waukau, at Eureka, on the east side of Fox river, south of Omro, and at different points in a ridge along the east side of Lake Poyagan, north of Winnekonna. Specimens of this rock were shown me at Appleton, from extensive ledges at Hortona, east of Wolf river, farther north. South of the head of Fox river, the country traversed by the lower magnesian, is mostly occupied by prairies, which form a connected series, from Middleton on the south, to Portage prairie, in Scott and Randolph on the north. I have observed this rock at different points on the latter prairie, and in Randolph, towards the east, lead has been found in it in sinking for wells, in two instances, in the same connection with flint and green marl, as on the northern border of the mineral district near the Wisconsin. The series of prairie is continued north east in the Green Lake and Ripon prairies, but these are rather in the range of the blue limestone, though large accumulations of limestone fragments are found upon their surface, apparently derived from the lower magnesian.

Outliers of this rock may occur at different points west of this frontier in the country occupied by the lower sandstone, but the only one I have visited is at Eagle Hill (Westfield,) in the north-west corner of Marquette county. The rock at this locality, though so remote from the main body of the lower magnesian, has the distinctive characters of that rock, its concretionary structure, and its peculiar geodic flints. It occurs there in two contiguous bluffs in which the rock has a large dip, on the whole, to the north, but on the west side more to the east, as if to a centre, and at one point on the south side of the west bluff, the lower sandstone is exposed, exhibiting characters peculiar to the point of junction. The rock is quarried for lime by Mr. R. M. Brown, and like the lower magnesian, generally gives a brown lime, slacking slowly, forming a strong mortar. Its remote position in a part of the country destitute of limestone, gives it a peculiar value.

The frontier of the lower magnesian, above indicated, sweeping around from the Mississippi, first east by the south side of the La Crosse valley, and then south-east to the Wisconsin near its bend to the west, and then bearing N. N. E. to the east side of Wolf river, is, if I mistake not, the limit towards the north of all the great limestone formations in the State; all the country beyond it, as far as I have proceeded being occupied by the lower sandstone, except in a few instances, where the primary rocks are exposed. The great curve to the south, at the bend of the Wisconsin, is connected with the exposure of the lower sandstone, near Madison, and with the remarkable denudation of the upper strata in the valleys of Sugar and Rock rivers, extending south into Illinois. These taken together would seem to indicate an extraordinary upheaval in that direction, which may be rendered more probable when certain facts pertaining to the arrangement of the lower sandstone, and of the primary and metamorphic rocks connected with it have been stated.

THE LOWER SANDSTONE.

This formation is apparently of very great thickness, and occupies a wide extent of country north and west of the frontier of the lower magnesian. It is far less uniform in its character than the upper sandstone, and includes a number of different beds, varying in composition from a pure silicious sandstone to a well marked limestone. It might indeed be regarded as a group of different formation, but to determine the precise position and extent of these would require a more detailed examination, rather than such a hasty reconnoissance as I have been able to make. In that part of the country east of the Wisconsin occupied by this formation the rock is very rarely observed, and appears to have been subjected to great denudation and concealed by drift. Farther west, towards the Mississippi, it has suffered less denudation and is much more exposed, but the denudation increases towards the north until as we approach the pineries only a few ridges and mounds remain, the greater part of the surface being there covered with drift. Beds of pure white silicious sandstone are found at different levels in this formation, sometimes quite thin, at other times of great thickness, but the greater part of the rock is less pure and apparently contains a portion of lime even where not obviously calciferous, in consequence of which the rock is generally less incoherent than the upper sandstone, and so better adapted for building. The pure silicious beds are generally as friable as the upper sandstone. The presence of lime in this rock may account for the fertility of the sandy soils in that part of the country occupied by it, which will appear remarkable to one accustomed to similar soils in other districts. The lime disseminated through this rock is often found in grains and concretions, the latter sometimes of a tabular from and traversing the layers vertically. Iron is also very generally disseminated through this rock, and the greater part of it is thus stained yellow or brown, and in many instances, parts of it are so iron shot as to be hard and heavy like iron ore. These iron shot portions usually occur as seams, and sometimes as tubes traversing the rock in different directions, and occasionally as layers or even as beds interstratified. A bed of this kind, of considerable thickness, and which might even be regarded as an iron ore, was observed by me near the dells of the Wisconsin river. The iron thus disseminated was probably originally in the state of iron pyrites, which sometimes is now observed unaltered. This rock, although sometimes as thick-bedded as the upper sandstone, particularly in the more purely silicious portions, is generally in thinner layers, and sometimes even thinly schistose.

The most remarkable feature in this formation is the occurrence of distinct calciferous beds, some of which may be regarded as truly limestones, and are burnt for lime, while others may be considered as marl or marly sandstone. Some of these are quite thin, while others are of great thickness, and might be regarded as subordinate formations. The oolitic structure is common to the calciferous beds in this formation, and is found largely pervading them, particularly the purer limestones, while in the higher limestone formations I have observed it only at their junction with the sandstones. This has appeared to me important in determining whether such beds in the tract generally occupied by this formation are subordinate to it, or continued from the overlying limestones towards the south. In these positions, where the lower sandstone is found overlaid by the lower magnesian, a calciferous bed, usually of considerable thickness, is generally found but little below the line of junction, but sometimes overlaid by a thin bed of pure white sandstone. At the base of the lower magnesian there are generally a number of marly and sandy layers, often oolitic, which mark its junction with the sandstone. The calciferous bed below varies from a marly sandstone through a thin soft marl to a thicker, nearly compact marly limestone. It is often stained green by iron, particularly near its surface and at the seams, particularly the thinner, more marly portion. Such beds I have observed well marked at Reed's Mills, in the bluff, on the west side of the Kickapoo, and in the ridge north of the village of Lodi. The sandstone quarried near Madison is a marly sandstone, in the same position, near its junction with the lower magnesian. I had not observed the latter rock overlying it previous to my last report, but in one of the quarries north of the railroad, I have this season found that rock distinctly overlying. The rock in this bed has always a peculiar yellowish tint, which may be considered characteristic. A similar calciferous bed is generally observed near the tops of the higher bluffs in the country east of the St. Croix, particularly in those near the Falls of the Kinnickinnic. These bluffs are from one to two hundred feet in height, and present distinctly the characters of the lower sandstone in the alternations of subcalcarious, and sometimes even thin limestone beds with the purer sandstone. It is beneath these high bluffs that a very extensive and thick bed of limestone is situated, occurring at different points along the east side of the St. Croix, from Prescott northward, which has been considered in Owen's Reports, as a continuation of the lower magnesian. The The consideration of this bed is important in dertermining whether the limestones of the upper Mississippi, which have been regarded as the same formation as the lower magnesian before discribed, are really so, or only subordinate to the lower sandstone. This bed extending along the Mississippi, above and below the St. Croix, and along the latter to within five or six miles of Hudson, evidently passes under the high sandstone bluffs above noticed, as it may be traced at the level of their base to within a short distance of them. The same bed obviously forms the Falls of the

Kinnickinnic, where it still more evidently underlies the numerous high sandstone bluffs in that vicinity.

It appears again at the falls of Willow river where it is deeply intersected and shows a great thickness as well as in the vicinity of Prescott. A bed of a similar limestone was observed by me, at a comparatively low level in the great woods west of the Menomonee, near the creek entering that river below Wilson's mills. This rock has appeared to me very different in its character from the lower magnesian. It generally shows more or less of the oolitic structure, like the smaller limestone beds which occur in the lower sandstone, where it is distinctly marked by its position relative to the lower magnesian. I have never observed in it the peculiar flint of the lower magnesian although geodes of quartz are not unfrequent. The sandstone which overlies it is of much greater thickness than the upper sandstone, and corresponds in character with the lower sandstone, particularly in the presence of lime either disseminated or in calciferous beds, resembling those occurring in that formation where it is unquestioned. Such a bed occurs at Winslow's quarries, on a ridge, two miles southeast of Hudson, at a much higher level than the great bed just noticed, and evidently subordinate to the sandstone; partly composed of a calciferous sandstone, and partly of a nearly compact limestone burnt for lime. Beds of this character of little thickness have been observed in the lower sandstone near its southern border, where it approaches the frontier of the lower magnesian, but at a lower level in the formation than the calciferous bed near its upper surface. Such a bed extends along a ridge on the west side of Sauk Prairie, near Otter creek, and another occurs near the Baraboo narrows, apparently of limited extent, and near the base of a high bluff of sandstone. The latter has been quarried for lime, but the lime from this as well as from the bed near Hudson, although it gives a strong mortar and might answer for cement, is more difficult to slack than that from the lower magnesian.

The considerations here offered have induced me to regard the great bed apparently extending from Prescott to Willow river, as subordinate to and at a considerable depth in the lower sandstone. A bed of a similar character, but of much less thickness, extends along the top of the bluffs at Stillwater, west of the St. Croix.—This bed is underlaid by sandstone, apparently the same as that in the bluffs overlying the former. Calciferous beds, but more of the character of calciferous sandstone, occur on Apple river, at McCarty's Prairie (Polk county) and at the Falls of the St. Croix. At the latter the sandstone is arranged in its usual nearly horizontal position, on the side of an abrupt ledge of the trap or greenstone forming the falls, and includes beds of a thin marly shale. The rock is more or less fossiliferous, and the shale nearly composed of shells. The *Lingula* is the most abundant and characteristic. I have noticed it at different localities in the lower sandstone, as far as Sauk Prairie, but always in calciferous beds or layers. I have in no instance observed fossils in the purer silicious sandstone. On the summit of a bluff, one or two miles west of the St. Croix, opposite Hudson, I observed in a quarry a bed of limestone abounding in shells, particularly *Leptænæ*, and resembling by these and other fossils, and even by its structure, the shell bed of the blue limestone, but evidently disconnected with beds resembling the other beds of that formation and immediately connected with a sandstone at the same level with that in the high bluff east of the St. Croix, which I have regarded as the lower sandstone. I was shown at Prescott a specimen of a *Leptæna*, from one of the high bluffs north-east of that place, indicating the presence of the same bed in that position. This shell bed has appeared to me also subordinate to the lower sandstone, but at a higher level than the beds before noticed. In proceeding through Minnesota from Prescott, by Hastings, to La Crosse, I observed beds of limestone in bluffs and ravines throughout a great extent, generally at a higher level than the great bed east of the St. Croix.

The general character of the rock was similar to that of the latter, and in no instance presented the peculiar characters of the lower magnesian. Where I had an opportunity of observing it distinctly exposed, it appeared to form a bed included in the sandstone. It appeared so in the bluff along the west side of Cannon river, and in different bluffs along the west side of the Mississippi and Lake Pepin, from Redwing to near the Zumbro river. On the prairies, it appeared only in points and ravines disconnected with other rock, but in a recent excavation on the government road, west of Lake Pepin, in ascending to the high prairie, it was distinctly overlaid by sandstone. In crossing the prairie, south of the Zumbro, the rocks appeared in the same disconnected manner as on the prairies farther north, but south of the Whitewater, it evidently passed under a range of sandstone bluffs, crossing the prairie from east to west. In crossing this range, I observed an overlying bed of fossiliferous limestone, perhaps analagous in position to that west of Hudson, but not marked like that by *Lepætnæ*, and immediately with a sandstone, having the characters of the lower rather than the upper sandstone, which continued to show itself near the surface, at a level corresponding to that in the bluffs south of La Crosse, passing under the lower magnesian. I have only given here a very general statement, sufficient to convey the impression made on me by the facts observed. I have thought it proper to state that impression in the hope that it may attract the attention of others who may have opportunity for a more detailed examination. It has appeared to me not improbable that those are different beds of limestone in the lower sandstone, some like the lower magnesian, containing few or no fossils, like the great bed east of the St. Croix, and the limestone extending on the west side of the Mississippi, south of the Whitewater, and others abounding in fossils like that at a low level, at the falls of the St. Croix, abounding in *Lingulæ*, and that at a higher level west of Hudson, analagous to the shell bed of the blue limestone. The lower sandstone, as we proceed east from the Mississippi, does not indeed present such remarkable beds of limestone as extend along the upper Mississippi; but calciferous beds occur there even in the vicinity of the Wisconsin. In that part of the formation the calciferous beds appear to be of limited extent. That at the Baraboo Narrows, offers an apparent instance of this, nor is the marly bed near the junction with the lower magnesian always equally developed. The lower sandstone in the country traversed by the upper Mississippi, may thus be more pervaded by beds of limestone which do not extend in an equal degree towards the east.

Layers occasionally occur in the lower sandstone, though unfrequently, containing rounded or flattened pebbles of quartz, often limped, apparently formed by attrition. These, so far as I have observed, are never large, and usually very small, and the latter particularly resemble concretions; still these, as well as the smaller grains of which the sandstone is composed, appear to have been rather the result of attrition. Such layers are usually thin, nor have I observed any thick beds of conglomerite in this formation.

The lower sandstone is more generally arranged in even horizontal layers, but in many instances I have observed an arrangement which I have not noticed in the other secondary formations. Layers or beds occur marked by oblique lines of stratification, and these in different directions, alternating with others in which the lines of stratification are regularly horizontal. This arrangement is strikingly exhibited at the Dells of the Wisconsin river; but may be observed in many other localities. In one instance, on the Chippewa, near O'Neil's creek, this arrangement appears to be undulatory, as if formed by the action of waves, but in most instances the oblique lines appear to extend only across the layer or bed. Such oblique lines, alternating with horizontal, I have observed in beds of drift sand.

Rocks apparently of metamorphic origin are observed in connexion with the lower sandstone. That most evidently connected with the sandstone is a white or slightly bluish compact quartz, resembling a primary quartz, either forming beds or layers in the white friable sandstone, or traversing the same vertically, in the manner of a dike. A very thick bed of such a quartz rock occupies the summit of a high bluff, west of the Trempeleau, by the stage road from Black R ver Falls to Hudson. This rock overlies the sandstone in regular strata, with thin layers of friable sandstone interposed, and even includes nests of the same in its mass. I have observed the same quartz in other instances, forming only thin layers, or limited deposites or nests interposed in the sandstone. A remarkable instance of an apparent dike of the same quartz rock occurs in the Musquito mountain, in the town of Almond, (Portage county,) two or three miles west of the Portage and Stevens Point road. This rock here extends in the manner of a vertical dike along the middle of a long narrow ridge, bearing nearly east and west, and is bounded on each side by lower terraces of friable sandstone, and is more or less blended with the latter, like the quartz bed on the Trempeleau. This dike would seem to have been formed along the line of a fissure by the action of some agent then escaping, capable of changing the sandstone into a compact quartz. Mounds of a granular quartz rock, including beds of iron ore, occur near Black River Falls, apparently emerging from the lower sandstone, and presenting some appearance of a metamorphic origin, but arranged nearly vertically, like the primary rocks of that vicinity. These will be noticed in connection with the iron ore of Black river. Several facts seem to indicate that the grey quartz rock of the Baraboo, and east of Portland, was also formed from the sandstone by metamorphic action, but I have preferred noticing it under a separate head.

The lower sandstone has been subject to great denudation, on the north and north east particularly, in the country east of the Wisconsin. North of a line which may be traced from the St. Croix, by Willow river, the upper part of the Kinnickinnic and

Rush rivers, across the point between the Menomonee and the Chippewa, and by the heads of the Buffalo river and the Trempe-lean, to Black River Falls, and thence north of the Lemonweir to the Wisconsin and Fox rivers. This rock is mostly concealed by sand or drift, and is exposed only in more or less detached ridges, or mounds, or in low swells or plateaus. Some of these ridges or mounds are singularly detached, such as the Roche a Cris, the Mosquito mountain and Pilot Knob, east of the Wisconsin. I have visited only the two last of these, and have there observed appearances which may account for their preservation amidst the general denudation. The Mosquito mountain appears to have been preserved by the dike of quartz rock traversing it, above noticed. The Pilot Knob is traversed in a similar manner by a narrow dike-like mass of rock, intersected throughout with seams of hermatite, and rising to a great height, bordered by lower swells of friable sandstone. This subject will be farther considered when I come to treat of the conformation of the surface.

Within the frontier of the lower magnesian, the lower sandstone is exposed only to a small extent, generally underlying the former in the bluffs along the rivers and smaller streams. It is not exposed on the Wisconsin at its junction with the Mississippi, but gradually rises in ascending that river, till it occupies more than half the height of the bluff at Clifton, opposite Sauk City.—It does not appear in the bluffs east of the Mississippi, till some distance north of Prairie du Chien, but rises to the tops of the bluffs south of La Crosse. It nearly reaches the tops of the bluffs adjoining the Kickapoo, at Reed's mills, and extends far back into the ravines. East from that stream it is more and more exposed till it occupies the tops of the ridges adjoining Sauk Prairie. The most remarkable exposure of the lower sandstone within the frontier of the lower magnesian, is that on the Fourth Lake, near Madison. The country from the Wisconsin to that point is apparently overlaid by the lower magnesian, but that rock is there denuded to a limited extent, particularly along the south side of the

Fourth Lake, and the lower sandstone exposed. This rock is quarried there near its junction with the lower magnesian, and is more or less calciferous, which renders it sufficiently coherent, and this with its fine grain, and other qualities as a freestone, will give it great value for building. The exposure of this rock seems to make a centre of elevation at that point, apparently connected with the basins of the lakes, and with the great denudation of the upper strata, extending through the middle of the strata, from north to south.

THE QUARTZ ROCK,

(*Of the Baraboo, and of Portland.*)

The quartz rock in the ridges adjoining the Baraboo valley, on the north and south, and that east of Portland, are so similar in character, that they may be considered in connexion. The rock, in both instances, is a light or dark grey hard granular quartz, marked more or less distinctly by parallel lines of stratification, and resembling much a primary granular quartz, but presenting certain peculiarities both in position and character, which seem to indicate it an altered sandstone. This rock, adjoining the Baraboo valley, lies within the limits of the lower sandstone and forms either detached ridges, in the range of ridges of the sandstone, or is more immediately connected in the same ridge with the latter. East of Portland, it appears in two parallel ranges, apparently detached from other rocks on the east side of a marsh traversed by Waterloo creek, on the west side of which the upper sandstone occurs overlaid by the blue limestone. In the Baraboo rock two characters are not unfrequently observed which appear to connect it immediately with the lower sandstone. These are the occurrence of layers more or less filled with rounded pebbles of quartz, usually very small but sometimes larger, precisely resembling the layers of the same kind in the lower sandstone, and also of obliquely cross lines arranged between the regular lines of stratification in the manner already noticed in the latter. These appearances, I have not observed in the Portland rock nor in the upper sandstone, with which that rock from its position might be regarded as connected. But the rock in both instances is so similar in general character as to render a common origin probable. In the Baraboo rock, cross veins and nests of white quartz, sometimes containing geodes of very distinct crystals are found in some localities, particularly in the ridge south of Devil Lake. Titanic iron resembling the *Crichtonite*, not unfrequent in primary quartz, is also found in that rock, generally in their seams, but one instance noticed in a ridge north of the valley east of Baraboo village occupying a vertical vein two or three inches thick. In the Portland rock, in its eastern range, I noticed cross seams at the joints of a dark green mineral resembling hornblende.

The quartz rock, adjoining the Baraboo valley, forms two ranges, one on the north, the other on the south, which are apparently connected on the east by a ridge of sandstone, closing the valley in that direction, the Baraboo passing through to the Wisconsin by the narrows, a gorge at the east point of the range of quartz on the north. The ridges of quartz rock are less elevated on the north and appear generally detached from the sandstone. On the south the ridge adjoining Devil's Lake on the east and west are more than three hundred feet in height and are parts of the same east and west range, deeply cleft at that point. These ridges also appear detached from the sandstone, but farther west on the same side of the valley I noticed a ridge of this rock at the summit of a high ridge chiefly composed of the sandstone. In general the bearing of the ridges is here east and west, and the dip as determined by the lines of stratification, but moderate to the north. If this rock was formed from the sandstone by ignious action from beneath, as the circumstances already mentioned seem to indicate, this metamorphic change does not seem to have been accompained by much disturbance of the strata, although from the great height of the hills surrounding the valley, particularly on the south and east, there may have been a general upheaval as at the centres of elevation in the mineral district. The quartz rock of Portland, is largely exposed in a low ridge on the east side of the marsh at Waterloo creek, and less so on the west side of a ridge about a mile farther east. The bearing of these ranges is south by east, and the apparent dip about twenty degrees east. By a recurrence to the map, it will be seen that the bearing of the quartz rock at Portland from that at the Baraboo, is about E. S. E.

THE PRIMARY ROCKS.

These in the part of the State which I have visited are confined to a few detached localities, some of which at least are connected in more extensive ranges. These localities are all within the limits of the lower sandstone, and most of them occur at the falls of the northern rivers. The lower sandstone appears in no instance to have resisted the action of the currents, but to have been deeply cut through, forming the Dells of those rivers. The harder primary rocks have, on the contrary, resisted that action, and whenever they have crossed the channels of the rivers, have formed falls or rapids. Generally these rocks are little elevated, but in a few instances they form ridges of considerable height. In most instances they are not observed in immediate connexion with the sandstone, but in a few instances, particularly in the banks of rivers, I have noticed the sandstone in such connexion, either overlying or on the sides of the primary ledges, but rather appearing to have been deposited subsequently to the formation of the latter than to have been disturbed by their intrusion. A few instances where the sandstone may seem to have been disturbed will be noticed incidentally. But though the sandstone would seem to have been deposited after the primary rocks had been formed, yet in several instances it has been apparently modified at its junction with the latter; either a thin band of white compact quartz such as has been already noticed in the sandstone adjoining the primary rocks, or the sandstone in that position appearing more lindurated or modified in color or composition. These changes do not, however, appear to have been the result of any decided igneous action.

The primary rocks which I have examined in this State, appear to be of the same class with those of New England. They present, indeed, as already stated, the most striking analogy to the latter, both in their character and combination, and appear to have been the result of the same general causes. Whether these causes have operated in the two instances, at the same general period, or at remote intervals, can only be determined by a minute examination of the circumstances attending each, but when so great a resemblance prevails, they might be presumed to be of the same period, without decided evidence to the contrary. I have already stated that I have not yet observed any trap rocks in the localities visited by me, analogous to the proper intrusive trap, or such as intersect rocks of a very different character, such as sandstones. The rock most nearly resembling such intrusive trap, namely, that which occurs at the falls of St. Croix, and in the vicinity, has rather the character and arrangement of the primary greenstones. In the other localities visited, where trap rocks have been indicated, I have observed only hornblende and sienitic rocks clearly primary in their character and connexion. Although the primary rocks generally occur only in detached localities of limited extent, yet these are not disconnected, but are combined in a number of groups or local formations, as in districts occupied by primary rocks exclusively. In my report on the geology of Connecticut, I endeavored to distinguish the local formations in the primary rocks of that State. Similar local formations may be clearly distinguished in the primary rocks of this State, although occurring only at detached points, separated by wide intervals of drift or sandstone.

An extensive range of primary rocks may be traced through the counties of Marquette and Waushara, commencing on the south of Fox river and extending N. N. E. towards Waupacca county.

This may be called a sienitic range, although including rocks varying from a light red sienitic, in which felspar predominates, to a dark green stone in which hornblende prevails, and even to a gneiss containing both hornblende and mica. These different rocks occur in distinct subordinate ranges. On the west is a range of red sienite, which I noticed on the south on the north side of Fox river at Montello, and then N. N. E. from that point in the town of Marion, in Waushara county. This rock is a compound of red felspar and dark green hornblende, in which the former largely predominates, sometimes with a little quartz disseminated. A parallel grain can be more or less distinctly observed; but the rock is generally solid and thick-bedded, very rarely showing a tendency to cleve in the direction of the grain. Cross veins and small nests of quartz occur more frequently at Marion than at Montello. The nests appear as secretions around which the rock is more purely felspathic. At Montello, the bearing of the rock is more nearly E. N. E., at Marion, more nearly N. E. At the former place, it forms a single ridge in which three distinct beds may be distinguished; one on the north, containing more hornblende, one in the middle more purely felspathic and very compact, and one on the south resembling the latter in composition, but coarser grained and more distinctly parallel in structure. At Marion, it forms three distinct ridges, two on the west and one on the east of Spring Lake: their relative bearing transverse to that of each. Numerous boulders of this rock are scattered on the surface in the vicinity of the ledges at Marion, some of large size. This rock might be used for building, and would generally form a very indestructible material, but it is too hard to be dressed to advantage. In a line farther east is a range of dark green stone, noticed towards the south-west in the Observatory, a high ridge in the town of Buffalo, south of Montello, and towards the north-east in two groups of ledges about half way between Marquette and Grand river, on the road to Montello.

This rock is very dark colored and nearly black; but its weathered surface is lighter, and often reddish. At the Observatory it is generally thick bedded, with a distinct parallel structure, and mostly fine grained and nearly compact; but sometimes coarser grained, when the parallel grains are more obvious. In the ledges near Marquette, the greater part of the rock is thick-bedded and fine grained like that of the Observatory, but sometimes black and smoothly compact, like a porphyry, with thin schistose layers interposed, partly even and more compact, partly uneven and more laminated. The rocks of this range might be taken at first sight for trap, but the parallel structure, and the arrangement is that of primary greenstone. This rock at the Observatory forms a high ridge, in which it is exposed at the summit and on the south, being concealed on the north by drift, and bears more E. N. E. like the rock at Montello. In the two groups near Marquette, it rises from the plain north of Grand river, in low ledges, bearing more nearly north east, while the bearing of the groups is nearly transverse to that of the ledges. The third range extends in a line still farther east, along a ridge on the east side of Fox river, in the immediate vicinity of Berlin. The rock is there a dark grey gneiss, with a distinctly parallel structure, but thick-bedded and very slightly schistose, with interlaminated hornblende and mica, with occasional porphyritic reddish felspar. Veins of quartz intersect it both transverse and interposed. This rock by its parallel structure, and its joints, breaks readily into flat blocks, and is thus valuable for building, but is not easily dressed. The bearing is nearly north east. The dip here, as well as in the two other ranges, is about eighty degrees west, or nearly vertical.

The two western ranges, it has been seen, apparently extend on the south-west in a more east north-easterly direction, and then bear more north-easterly. The eastern range has been noticed only at one point, east of the more northern part of the two western ranges, and has the same north-easterly bearing. These three ranges may be regarded as one connected formation, in which hornblende is the characteristic mineral on the west side, subordinate to felspar, in the middle predominant, and in the east accompanied with mica. The different parts are here remote, but in another instance, at Black River Falls, a similar arrangement will be noticed within a narrow compass.

The next point towards the west, where I have observed the primary rocks, is in the vicinity of Stevens' Point. I have visited there only three localities, viz: at the falls at Stevens' Point, and at the head of Conant's rapids, about three miles below, on the Wisconsin, and at Grier's mill, on Plover creek, E. N. E. of Stevens' Point. In the rocks of all these localities, mica is predominant and hornblende only subordinate. The prevailing rock at the two localities on the Wisconsin is gneiss, either light grey granitic, or dark micaceous in alternate beds, with veins and beds of granite, and more rarely of sienite, and a few beds of hornblende gneiss. At the falls at Stevens' Point, the rock at the foot of the falls on the east side is a hard, thick bedded dark gray, of submicaceous gneiss crossed by a large oblique vein of hard red sienite, with seams of epidote. In a ravine south-east, the rock is a rather lighter grey gneiss, with a white felspar (albite) decomposing readily to a soft clay intersected with small oblique veins of a hard red felspathic granite, and of a white felspar, decomposing to a clay, and with a few rich veins of a red sienite. It is worthy of note that the sienite at this locality contains a few scales of mica disseminated. At the head of Conant's rapids, on the east side, the rock is chiefly a light grey subgranitic gneiss, with few veins, with alternate beds of dark micaceous gneiss, more intersected by layers obliquely cross veined, and by smaller interposed veins and nests of red granite and quartz, and including thinner bands of hornblende gneiss. The south side of the ledge is much decomposed, like the rock in the ravine at Stevens' Point. This ledge is overlaid with sandstone, and at the junction there is a layer of a nearly compact white quartz, such as has been already noticed in the lower sandstone. The rock at McGrier's mill is a nearly uniform thick bedded light grey granitic gneiss, not fossile, and breaking in large blocks by jointed seams. It has the composition and appearance of a granite, but with a distinctly parallel grain, and more or less porphyritic, with a reddish felspar.

The porphyritic crystals are partly double and partly single, with minute scales of mica disseminated, both of which appearances are noticed in the porphyritic rocks of New England. This rock is generally subject to decomposition at its surface, but some of its beds are less so. It might be quarried with facility, and if it were not for the defect just mentioned, would be valuable for building. The general bearing of the primary rocks near Stevens' Point, is nearly east and west, varying from E. N. E. to E. S. E., and the general position nearly vertical.

The next group of primary rocks towards the west visited by me is that of Black River, extending upwards from the falls. In this hornblende is the characterestic mineral, and the rocks are sienite and greenstone accompained with chlorite slate. The falls are formed by a sienite composed of red felspar and dark green hornblende, the weathered surface light red, the interior darker from the hornblende. This extends up the river about a mile where it occupies the west side opposite Lewis' iron mound and is there bounded on the east by a band of dark greenstone, partly schistose, and even or contorted and partly thick bedded, and this by a band of thin dark green chlorite slate in the east bank immediately adjoining on the west the bed of iron ore in the mound. This bed is apparently bordered on the east by the same chlorite slate but is nearly concealed on that side by drift. The chlorite slate is accompained with bands and seams of red ochre and hematite, apparently the result of decomposition. North of the mound the chlorite slate crosses to the west bank accompained with the same red ochre and hematite, and farther north disappears under the sandstone. At Hamilton's mills, eight miles north, the primary rocks are again exposed and consist mainly of a very felspathic sienite with only slight traces of hornblende, chiefly red felspathic, but with white felspathic bands. The red felspathic rock partly distinctly porphyritic. On the east side the rock is traversed by bands of a chloritic slate partly dark green and thinly fissile, partly light green and thick with disseminated pyrites. At the Angles, one or two miles above, the primary rocks are again exposed, and consist chiefly of a thick bedded hornblendic gneiss or greenstone, darker in the interior, but weathering lighter on the surface. This rock is generally even and uniform, and with a distinctly parallel structure. It is bounded on the west by a thin dark green chlorite slate and includes a very wide interposed bed consisting of two parts intimately connected, that on the west composed of a very fine grained or compact nearly black trap like greenstone, and that on the east of a very fine grained red felspathic sienite with a band of compact red felspar resembling a porphyry. This bed appears regularly interposed, and obviously an original constituant of the primary rocks. The primary rocks are exposed at different points higher up the river, but I have not extended my examinations any further.

Quartz veins and nests occur more or less in all the sienitic and other hornblendic rocks from the Falls to the Angles, and some of those at Hamilton's Mill include segregations of felspar. The general bearing of the primary rocks of Black river is north by west, the dip west nearly vertical. The iron ores of Black river might here be noticed, as they are partly connected with one of the primary rocks above described, but the consideration of them will be deferred to their place under the head of metalic ores.

On the Chippewa I visted only two localities of primary rocks, namely, at Chippewa Falls and at the Vermillion Falls or Armontager's rapids. The rock at Chippewa Falls is a granitic gneiss or stratiform granite, with a distinctly praralle grain, bearing northeasterly with a dip west nearly vertical. This rock is generally light grey with white felspar, but in some layers darker grey and more micaceous. It is crossed more or less obliquely by small veins of red felspar granite and of quartz. Cross bands intimate ly connected with the main rock in structure, very hard and fine grained dark grey, breaking by joints in obliquely prismytic fragments and chiefly composed of felspar. A similar very fine grained red felspar band was noticed with a little hornblende disseminated. The weathered surface of the rock is lighter than the interior, and often stained reddish. In some parts, where quarried, black seams apparently of specular iron are observed in the interior, which near the surface are changed to red ochre. This rock breaks by joints in large regular blocks and may be quarried for ordinary uses in building, but is less easily wrought than granitic rocks of a less parallel structure. At the Vermilion Falls the ledges are composed of a very dark, nearly black schistose rock, varying from a micaceous to a hornblendic gneiss; on the south more micaceous, on the north more hornblendic. The bearing of the rock is E. N. E., the dip north, nearly vertical. In the southern ledges, the rock is in part simply micaceous, and in part micaceous with interlaminated hornblende, in the northern ledges a hornblende gneiss with more or less interlaminated mica. This rock is traversed both on the north and south by large interposed beds of coarse red or reddish white felspar granite with veins and nests of white quartz, and by small interposed seams of white and reddish felspar.

The rocks known as Trap, forming the Falls of St. Croix, and traversing the adjoining county, through a large extent, may be here noticed in connexion with the primary rocks to which it has much analogy in its arrangement. A parallel grain can be more or less clearly distinguished in this rock corresponding with the strike of the ledges, and generally bearing E. N. E. with a nearly vertical dip north. Small nests of quartz and red felspar, the last giving to the rock a porphyritic appearance, and segregations differing in color and texture from the rock in general may be sometimes observed in the direction of this grain, indicating a stratiform arrangement, as in the primary greenstones. This rock is distribeted over a wide extent of surface, and presents groups of ledges, arranged transversely to their direction, as has been noticed in the sienite and greenstone rocks near Fox river. It has however the general character of trap rocks, and sometimes presents an amygdaloidal structure peculiar to those rocks, and such as I have not observed in the proper primary greenstones. It may be regarded as intermediate between the latter and the trap rocks distinctly known as intrusive. This rock is generally dark green or nearly black, fine grained and very hard, but sometimes coarser grained and then more decomposible. It is generally very solid, breaking only by joints in larger blocks, but sometimes breaks in smaller jointed fragments. Although generally uniform in character it is sometimes much pitted with seams and nests of quartz and red felspar or with seams and nodules of a light yellow, like epidote, very hard and compact, sometimes giving to the rock the appearance of a breccia or conglomerate. These latter, as well as the red felspar, are more characteristic of the primary than of the proper trap rocks.

The different localities visited by me may be here briefly noticed. A remarkable range crosses McCarty's Prairie, extending nearly a mile east from the Hudson and Falls road, but narrow, generally presenting only two lines of ledges, but at its east end two other ledges project to the north. These ledges have nearly the same easterly bearing. * * * *